



**An overview of current non-nuclear radioactive waste management in the Nordic countries and considerations on possible needs for enhanced inter-Nordic cooperation**  
Final report from a NKS-B activity commissioned by the Nordic Council of Ministers

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An overview of current non-nuclear radioactive waste management in the Nordic countries and considerations on possible needs for enhanced inter-Nordic cooperation

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## **Abstract**

This report is the final deliverable of a project commissioned by the Nordic Council of Ministers for NKS to assess the current situation in the Nordic countries with respect to management of non-nuclear radioactive waste. The ultimate goal was to examine if any needs could be identified for enhanced Nordic cooperation within the area. The radiation safety authorities in the Nordic countries were all asked to produce a current status report including thoughts about possible needs for enhanced cooperation. The material was presented and discussed at a meeting in Copenhagen of representatives of NKS and the Nordic authorities, and a number of ideas were derived with the perspective of possible further cooperation between the Nordic countries on the regulatory level, whereas more scientific based new work ideas were thought to be suited for an activity application for the next NKS call for proposals, in the autumn of 2015.

## **Key words**

Radioactive waste, non-nuclear, waste management, NORM, Nordic co-operation, orphan sources, sealed sources, scrap metal sources, geological disposal

01 June 2015

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## Introduction

The present draft report describes the results of a project commissioned by the Nordic Council of Ministers (NCM) for NKS to examine whether there are needs for further collaboration between the Nordic countries on issues related to radioactive waste. It was specified by NCM that all types of radioactive waste, except those arising from nuclear power production and any plans regarding emergency preparedness should be considered in the investigation.

As agreed with the NKS Board, the request from NCM was discussed at the meeting of the Directors of the Nordic Radiation Safety Authorities on the 20<sup>th</sup> of August 2014. In accordance with the recommendations from this meeting and the previous NKS Board meeting it was decided that NKS would oblige the request by organising a meeting between specialists representing the radiation safety authorities in each Nordic country. Each authority was requested for this purpose to provide a short report giving an overview of the national situation regarding non-nuclear waste at the meeting. Needs for further collaboration were also to be discussed at the meeting. If needs were identified, proposals for new collaboration plans on specific sub-topics would be outlined as possible.

Regarding the national overviews of production, handling and storage of radioactive waste, the following instructions have been given to each national director on 2014-11-07 to distribute to the national participant:

*The overview should be brief (ca. 2-4 pages) and comprise essentially all important types of classified radioactive waste, **except** those relating to nuclear power production and to any plans regarding emergency preparedness.*

*For each waste classification category (e.g., high, intermediate, low level, special, tailings,...) it would be useful if all national experts would cover the following points:*

- 1) Description of typical annually generated volumes and materials of waste, primary radionuclides and indications on radioactivity level range, primary producer categories*
- 2) Description of primarily applied waste treatment techniques, existing repository capacity/use (interim/final), repository types/designs by waste type.*
- 3) Foreseen future waste management issues (foreseen changes in production, plans for new waste handling and storage techniques and capacities, etc.)*
- 4) Special national legislative issues*
- 5) Current collaboration within the Nordic community and in wider context*
- 6) Identified benefits from enhanced Nordic collaboration in the field if any (please note: this is the essential point, which the NCM would like to have addressed; it should also be the main focus point in the discussions on the day of the meeting).*

The national overviews were received a few days before the meeting, which was held on the 9<sup>th</sup> of June 2015, at Hotel Park Inn by Radisson Copenhagen Airport, thus facilitating the discussion. The Nordic authorities were represented at the meeting by Sigurður M. Magnússon (IRSA), David Garf Ulfbeck (NIRP), Mika Markkanen (STUK), Jelena Mrdakovic Popic (NRPA), and Erica Brewitz (SSM). Sigurður M. Magnússon, Finn Physant and Kasper Andersson represented NKS.



## Summary and conclusions on the work

At the meeting in Copenhagen, presentations were given of each requested national overview (national reports are to be included in Appendix A, and presentation slides are to be included in Appendix B of this report). Obviously, the different countries have different basis for waste management and disposal, for example since Finland and Sweden are nuclear power producers, and repositories thus exist, which can also be used for certain amounts of non-nuclear radioactive waste. Nevertheless, it should be noted that repositories in these countries are owned by private companies, and that these are not necessarily required to accept all types of radioactive waste from non-nuclear applications. In Denmark, all radioactive waste is managed and stored by Danish Decommissioning at the Risø site. In Norway, an important waste storage facility (IFE treatment and storage facility in Himdalen) also combines non-nuclear waste with that arising from research reactors (contrary to the Danish still operational), but also other facilities are here licensed for disposal of radioactive waste. In Iceland, the radioactive waste has very low volume and specific activity, and this does not justify having a national final waste disposal site. It is also clear from the material presented that there are considerable differences between Nordic countries in the amounts produced of different types of non-nuclear radioactive waste, and that new developments are changing the picture somewhat. For instance, the planned European Spallation Source in Lund, Sweden, which is scheduled to start operation in 2025, is estimated to produce some 11,000 m<sup>3</sup> of waste from its operation and decommissioning 40 years later, corresponding to about 15 % of the total planned space of SKB's two disposal facilities.

In the second half of the meeting, the sections of the national reports containing declarations of interest for possible enhanced Nordic collaboration were examined and discussed. Table 1 (based on the national reports) was handed out to the meeting participants to clarify where common interests lay.

**Table 1. Overview of areas of declared Nordic national interest for enhanced inter-Nordic collaboration on non-nuclear waste issues**

	Sweden	Denmark	Finland	Norway	Iceland
NORM	Management, disposal	Management, disposal	Management, recycling, disposal	Legislation, monitoring, management, disposal, risk assessment, protection, BSS	Interest expressed
Consumer products (incl. smoke detectors)	Management, recycling, disposal	Management, disposal		Interest expressed	Interest expressed
Uranium and thorium by-products	Interest expressed			Interest expressed	
Orphaned or legacy sealed sources		Interest expressed	Interest expressed	Interest expressed	Interest expressed
Scrap metal sources		Interest expressed	Interest expressed		
Spent sealed sources			Interest expressed		

The primary expressed interests were in experience sharing and possible development of common approaches. All Nordic countries have expressed interest in expanding the collaboration on NORM waste management and disposal. This was even the case for Iceland, where natural radioactivity levels are obviously very low, but where it has recently been found that deep drilling beyond the volcanic soil crust for geothermal energy production has resulted in NORM scales building up on the water pipes. The discussion resulted in identification of a number of ideas for further regulatory cooperation between the Nordic countries. It was thought that these might suitably be presented to the Group of Directors of the Nordic Radiation Safety Authorities at their meeting in August, to possibly initiate a formal collaborative programme. However when presented with the conclusions of the meeting on the 12th of June 2015, the recommendation from the NKS Board was that each member of the work group 'air' and shape the ideas further up in their organisation before they are discussed at the highest level between the Nordic authority organisations.

The specific NORM related questions were as follows:

- When should NORM waste be managed as radioactive waste? (particularly the 1-10 Bq/g area seems 'grey' and management may be subject to volumes, content of other stressors, etc.)
- When should radiological considerations be taken into account in the management of NORM waste?
- Which differences currently exist in these contexts, and what are the reasons for the differences?
- Which management solutions are implemented in the Nordic countries (disposal, storage, recycling)?
- Which criteria are the solutions based on?
- Which feedback from experimental experience in relation to radioactive waste recycling options are important to consider?

In addition, it was stressed that Am-241 sources (e.g., but not predominantly from smoke detectors) present a particularly challenging problem due to the very weak gamma line that severely complicates their detection. It was found to be particularly beneficial to work for a common understanding of the benefits and possibilities for recycling Am-241 sources, which would reduce the likelihood of such sources ending up in scrap yards or other places where they do not belong. It was also felt that both recycling facilities and the public could be better informed of the perspectives.

In relation to scrap metal sources, it was pointed out that these may be delivered by small companies or private persons, and it may not be reasonable to ask the finder to pay for the management and disposal. Who will pay – will the state? A small comparative survey could be beneficial of the practice in the different Nordic countries. Perhaps the Group of Directors of the Nordic Radiation Safety Authorities could even issue a common Nordic statement on a general policy for dealing with sources in scrap metal. It was felt that this would be highly beneficial.

Also a proposal for possible research and development work emerged, related to practical solutions for recycling of NORM. If the NORM is for instance mixed in a road paving what should be considered? Here it would be useful to make Nordic use of the considerable experience in some of the countries in relation to testing of different recycling options. For example, case studies have been conducted (and more could be conducted) where the potential contaminant migration has been monitored including all possible migration pathways, including investigations of important environmental parameters, and baseline studies. A

catalogue of examples of potentially successful solutions would be very useful, including descriptions of the local conditions and an evaluation of which other types of area conditions the method would be recommendable for. It was further discussed that if NORM is applied as a road construction material, the road would at some point in time anyway need to be demolished. As many important NORM radionuclides have long half-life it could thus be argued that the problem would in this way merely be postponed to a time, where the expertise required to deal properly with it could not necessarily be guaranteed. It would also be prudent to include in the catalogue any investigations and recommendations to keep track of non-radiological risks and decision factors, which could take very different forms (e.g., heavy metals and other non-radioactive pollutants, and risk perception) and make some recycling options impracticable in reality.

This latter, practical NORM proposal was seen as an idea that might be developed into an NKS activity proposal for the autumn's NKS call for proposals (possibly in some type of collaboration with NCM). Each meeting participant from a Nordic authority organisation agreed to identify a national participant for the NKS activity proposal work group.

The key representative of NCM in this work was Anna Maria Hill Mikkelsen.

## **Agenda for the Nordic Meeting to Assess Possible Needs for Further Nordic Collaboration on Radioactive Waste Issues, Copenhagen, 9 June 2015**

Place and time: Park Inn by Radisson Copenhagen Hotel, Engvej 171, DK-2300 Copenhagen S, Denmark, [www.parkinn.com/hotel-copenhagen](http://www.parkinn.com/hotel-copenhagen), 10:00 to 15:30

10:00 – 10:20	Welcome and introduction (Coffee and breakfast available)
10:20 – 10:45	National contribution from Denmark (presentation by David Garf Ulfbeck, NIRP, incl. 5 minutes for questions)
10:45 – 11:10	National contribution from Finland (presentation by Mika Markkanen, STUK, incl. 5 minutes for questions)
11:10 – 11:35	National contribution from Sweden (presentation by Erica Brewitz, SSM, incl. 5 minutes for questions)
11:35 – 12:00	National contribution from Norway (presentation by Jelena M. Popic, NRPA, incl. 5 minutes for questions)
12:00 – 12:25	National contribution from Iceland (presentation by Sigurður M. Magnússon, IRSA, incl. 5 minutes for questions)
12:30 – 13:30	Lunch
13:30 – 14:30	Discussion on possible benefits from enhanced Nordic collaboration in the field. Possibly outline of proposals for new collaboration plans on specific sub-topics
14:30 – 14:45	Coffee and cake
14:45 – 15:30	Discussion continued and wrap up

## **Appendix A: National reports from each of the Nordic countries (presented prior to the meeting)**

A.1. Denmark . Management of radioactive waste of non-nuclear origin (David Garf Ulfbeck, National Institute of Radiation Protection, Denmark)

A.2. Finland: overview of production, handling and storage of non-nuclear radioactive waste (Mika Markkanen, STUK - Radiation and Nuclear Safety Authority, Finland)

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A.5. Overview of non-nuclear radioactive waste in Sweden (Erica Brewitz, Swedish Radiation Safety Authority, Sweden)

## Appendix A.1.

05. June 2015

### Denmark – Management of radioactive waste of non-nuclear origin

Following the request from the Nordic Council of Ministers for an investigation of possible needs for further collaboration on non-nuclear radioactive waste issues, this document presents a summary overview of the policy and practice for management of non-nuclear waste in Denmark.

#### Policy and legislation:

The Danish legislation for radioactive waste management is comprised in the following Acts and Ministerial Orders etc.:

- Act No. 94 of 31 March 1953 on use etc. of radioactive materials.
- Ministry of the Interior and Health (now Ministry of Health) Order No. 192 of 2 April 2002 on exemptions from Act on the use of radioactive substances.
- National Board of Health order no. 954 of 23 October 2000 on the use of unsealed radioactive sources in hospitals, laboratories etc.
- National Board of Health order no. 985 of 11 July 2007 on the use of sealed radioactive sources
- National Board of Health order no. 154 of 6 March 1990 on smoke detectors and consumer products containing radioactive materials with amendments in orders no. 547 of 23 July 1993 and no. 793 of 19 October 1999.

On 09 July 2013, Denmark notified the European Commission about the implementation of Directive 2011/170/Euratom into Danish legislation through the above mentioned Acts, Orders etc., and supplemented by the following documents:

- Order No. 1510 of 15 December 2010 on environmental impact assessment of certain public and private facilities (EIA).
- Circular letter of 21 December 2011 from the Minister for Health to the Nuclear Regulatory Authorities.
- Motion B 48 of 13 March 2003 on the decommissioning of the nuclear facilities at Risø National Laboratory.
- Minister for Health Statement R4 of 15 January 2009 to the Parliament on the basis for decision for a Danish repository for low and intermediate level waste.

The policy and practice for radioactive waste management supported by these acts, orders etc., is to collect, characterize, manage and store all Danish radioactive waste under safe and secure conditions in dedicated storage facilities. The national operator responsible for radioactive waste management in Denmark is Danish Decommissioning. The storage facilities are located at the Risø site, where the former research reactors and supporting facilities are presently being decommissioned. All radioactive waste, whether of decommissioning or non-nuclear origin is received, managed (conditioned, volume reduced, repackaged etc. as appropriate) and stored at the Risø site until a long-term solution for radioactive waste management in Denmark is established.

In 2003 it was decided (by the adoption of Motion B 48, above) that the aim of the policy should be to establish a final repository for all radioactive waste (nuclear as well as non-nuclear) in Denmark.

As part of the process, three preliminary studies; a technical survey of disposal concepts, a radiological risk assessment for transport of radioactive waste in Denmark and a geological siting survey to identify potential disposal areas, were conducted. The findings of the geological siting survey identified 6 of areas as geologically suitable for hosting a repository. Following this, an extensive public and local political debate arose, and in January 2013 a revised scheme for defining a long term management solution for the Danish radioactive waste was agreed upon. According to this scheme, the initial efforts for establishing a Danish repository were to be continued. In addition the options for establishing a long term storage solution (intermediate storage) were to be explored. Lastly, the possibilities for finding an international solution for the Danish radioactive waste were to be investigated. In March 2015 the efforts to find an international solution were ceased, and the political decision was to suspend work on establishing a Danish repository, until further studies regarding an intermediate storage solution are completed. Hereafter, a final political decision will be taken regarding either implementing a disposal or an intermediate storage solution.

### Practices

The complete Danish radioactive waste inventory is, both in terms of activity and mass, completely dominated by the waste generated from the decommissioning of the research reactors and supporting facilities at the Risø site. The waste management plant at Danish Decommissioning receives approximately 6-8 m<sup>3</sup> of waste from external producers (hospitals, industry users, laboratories, universities etc.) per year. The majority of waste from external producers consists of laboratory utensils, disposables etc. A small number of sealed sources which could not be returned to the manufacturer are also received from industry. With the increasing awareness about sorting of waste in Danish society, a growing number of smoke detectors become part of the Electronic Equipment waste stream or pass from various recycling facilities to the waste management plant at Danish Decommissioning. The main sources of radioactive waste, other than decommissioning, stem from the use of radioactive sources in research, medicine and industry. Waste generated from these activities follow diverse waste streams, as described below.

### Unsealed sources

All management of unsealed sources, including unsealed sources designated as waste, is regulated through National Board of Health order no. 954. Unsealed sources are primarily used in research and medical applications, and the majority of wastes generated from these activities occur in such small quantities or low concentrations that disposal of gaseous or liquid wastes may take place directly to the atmosphere or to the sewage system, if necessary, after a short period of decay storage. Unsealed solid sources are delivered to the waste management plant at Danish Decommissioning.

### Disused sealed sources

All management of sealed sources, including sealed sources designated as waste, is regulated through National Board of Health order no. 985. According to the order, the majority of sealed sources are to be returned to the manufacturer by the end of their useful life. Disused sealed sources are on rare occasions found in metal scrap. To date, radioactive sources have been detected by means of portal monitoring systems installed at major scrap yards, and such monitoring systems are recommended in advisory material distributed to the scrap dealers. A strategy for management of disused sealed sources in the scrap industry

is under development. In this regard contacts have been made to the Danish association of recycling industries in order to establish a more detailed understanding of the scrap flow. Emphasis is placed on the procedures at major scrap yards serving as collection points for minor scrap dealers. Orphan disused sealed sources are managed by the waste management plant at Danish Decommissioning.

At the administrative level, a national data integration interface combines data for relevant individuals in Denmark with the Danish Central Business Register (CVR) to enable a proactive and timely intervention by the authorities in case of bankruptcy, or discontinuation for other reasons, of companies possessing radioactive sources.

#### **Smoke detectors**

The adoption of council directive Council Directive 2002/96/EC of 27 January 2003, classifying disused smoke detectors as electronic waste, resulted in a change in the waste stream for the estimated Danish inventory of approximately 6 million smoke detectors at the end of their life-cycle. The previously employed practice of disposal of smoke detectors via the conventional waste incinerator facilities, in accordance with National Board of Health order no. 154, is now being replaced by inclusion of these Am-sources in the Electric/Electronic Equipment waste stream/separation for recycling. This introduces risk of contamination of the Electric/Electronic Equipment waste stream, for instance by the shredding of the Am-241 sources. As a result, an evaluation is underway of the potential radiological impacts of the increasing numbers of smoke detectors containing Am-241 accumulating at scrap yards as these types of smoke detectors are being phased out.

#### **Radioactive waste from NORM**

Approximately 5000 m<sup>3</sup> of tailings from uranium extraction research carried out in the 1970's and 80's are stored at the waste management plant at Danish Decommissioning. The material was designated as "potential" waste in the parliamentary decision to establish a final repository from 2003. The designation implies that no final decision has been made for the management of this or other NORM materials designated as waste.

In the North Sea, NORM materials accumulate as scale deposits on the insides of piping.

During maintenance operations and decommissioning of oil and gas production facilities, piping and other equipment with potential NORM contamination is routinely characterized, in order to ensure allocation in the proper waste stream.

However, routine inspections by RPOs on North Sea platforms or radiation portal monitor alarms in scrapyards show that a review and update of the present monitoring program is warranted.

Under the auspices of NKS, Swedish, Norwegian and Danish radiation protection authorities have entered a collaboration with the Danish technical university, DTU NUTECH and two major Danish oil and gas operators to define the project CONCORE (Characterization of NORM Contaminated Objects: Reliable & Efficient). NKS committed 400.000 DKK in 2014 and 363.000 DKK in 2015 for the realization of this project.

The characterization procedure to be developed during this project may potentially find use in other industries, where non-standard methods for radiological characterization may be required.



### **Nordic collaboration**

Some areas of collaboration already exist between Nordic countries, as exemplified above, regarding NORM. However, other areas of exchange of experience and information regarding radioactive waste may prove beneficial. Examples of such areas could be:

- Experience feedback regarding management of radioactive waste, orphan sealed sources, smoke detectors, contaminated objects etc. in the scrap metal industry.
- Experience feedback regarding management of smoke detectors in the Electric/Electronic Equipment waste stream.
- NORM management and development of disposal options

## Appendix A.2.

### Finland: overview of production, handling and storage of non-nuclear radioactive waste

Mika Markkanen

STUK - Radiation and Nuclear Safety Authority

Radiation Practices Regulation

December 19, 2014

#### General

The Finnish radioactive waste classification system includes two main categories: nuclear waste, and radioactive waste not originating from the use of nuclear energy and the associated nuclear fuel cycle. In this paper the latter is denoted as non-nuclear waste. Waste classification according to disposal route is illustrated in the figure below.

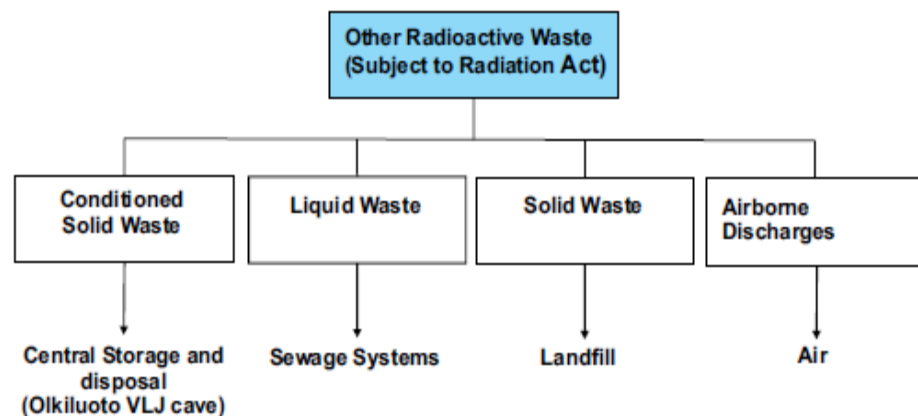


Figure 3. Classification of radioactive waste for disposal purposes.

Non-nuclear radioactive waste is regulated in the framework of the Radiation Act 592/92. According to the Act (Section 10), the term radioactive waste denotes radioactive substances, and various items that have no use any more and have to be rendered harmless due to their radioactivity. The definition also includes equipment, goods and materials that are contaminated by radioactive materials. Radioactive substances and radiation appliances containing radioactive substances shall also be regarded as radioactive waste also in case the owner of the substances or the appliances cannot be found.

User of radioactive substances shall render harmless the radioactive waste arising from the operations in question, including those involved with NORM (Naturally Occurring Material). A financial security shall be furnished for a sealed source or other radioactive waste with substantial liability. The Radiation Act also provides for the responsibility of decontamination of the environment, if the radioactive material is released in such an extent that the resulting health or environmental hazards require action.

The State has the secondary responsibility of the waste in case the producer of radioactive waste is not capable to fulfil his management obligation, or if the origin of the waste is unknown, or no primary responsible party can be found.

The Radiation Act prohibits the import of radioactive waste for the purpose of disposal.

In Finland, non-nuclear radioactive waste containing either artificial radionuclides or NORM is generated mainly from the following practices and activities:

- Uses of radioactive sources in medicine, industry, research etc., including production of isotopes
  - disused sealed sources
  - unsealed sources, e.g. short lived laboratory waste and authorized airborne or liquid releases
  - decommissioning waste (e.g. contaminated structures)
- Mining and milling industry, and processing of NORM raw materials
  - NORM waste, especially milling tailings
  - liquid or airborne releases
- Scrap metal industry
  - radioactive objects detected within the scrap (NORM and artificial)
  - waste arising from unintentional melting of radioactive sources (mainly slag and dust)
- Uses of radioactive sources in some consumer products
  - disused smoke detectors

These different waste types are discussed separately in the following chapters.

## **1. Uses of radioactive sources**

### *Disused sealed sources*

When new sources are authorized for use, STUK requires the applicant to present a plan on measures to be taken when it becomes a disused source. Essentially there are two main options; either to have an agreement with the provider on returning the source, or to transfer the source to the central storage facility at the cost of the licensee. The first option is preferred and it is foreseen that in the future an agreement on returning the source to the provider shall be required for all sources.

For HASS-sources (High Activity Sealed Source, as defined by Directive 2003/122/Euratom) a commitment from the manufacturer to accept the returning of the source once it becomes disused, is a condition for granting license for its use. In addition, a financial security is required for sealed sources whose activity exceeds the activity levels established in the said directive by a multiplier of 100 or more.

The TVO nuclear power company has leased to the State a cavern in the LILW disposal facility at Olkiluoto for interim long term storage of non-nuclear radioactive waste. The amount of

stored waste cannot be more than 100 m<sup>3</sup>. The current inventory is 56 m<sup>3</sup> (50.14 TBq, prominent nuclides: <sup>3</sup>H, <sup>137</sup>Cs, <sup>85</sup>Kr, <sup>241</sup>Am, <sup>238</sup>Pu; situation at end of 2003). The annual accumulation of new conditioned and packaged waste varies between 1 – 3 m<sup>3</sup>.

Most of this waste can also be disposed of in the disposal facility in the future based on the revised (in 2012) operation conditions of the Olkiluoto LILW disposal facility. A few HASS sources will need a different disposal route, which is not yet determined.

Disused sources are collected by a private entrepreneur, 'Suomen Nukliditeknikka', by whom they are repacked, as necessary, and then transferred to the storage at Olkiluoto. STUK has issued an authorisation based on the Radiation Act to Suomen Nukliditeknikka for its operations as a recognised installation.

Sources manufactured in Finland can be returned to Finland once they have become disused sources.

#### *Unsealed sources*

In practice, most of the wastes from the use of unsealed sources in Finland arise in such low activity concentrations or amounts that it is not necessary to arrange the disposal of the generated waste in the same way as e.g. for the sealed sources. A common practice is that radionuclide laboratories store their short lived radioactive wastes at their premises until they have decayed below the limits set for discharges in Guide ST 6.2. According to Guide ST 6.2, liquid waste can be disposed of into a sewage system and solid waste can be delivered to a landfill site or an incineration plant, if the activities are below the nuclide specific limits presented in the guide.

#### *Decommissioning waste*

Apart from taking care of the disused sealed or unsealed sources in a manner described above, there are a limited number of non-nuclear facilities where other decommissioning waste, such as contaminated structures, would occur. Where appropriate, normal clearance levels established by STUK (given in guide ST 1.5, numerical values based on the IAEA RS-G-1.7 values) have been applied. Where these values have exceeded, STUK has accepted – from the radiological protection point of view - some individual disposal plans, on case by case basis, for the disposal of some limited amounts of decommissioning waste (typically order of a few m<sup>3</sup>) to a normal industrial waste site. In these cases, the final approval for the disposal has been granted (considering STUK's acceptance) by the Environmental Authorities who regulate the disposal sites as a whole.

## **2. Mining and milling industry, and processing of NORM raw materials**

Currently there are only few running mining and milling operations involving NORM. Recently the most important case has been the Talvivaara mine producing nickel and zinc. During the production processes uranium ends up to the gypsum waste water pond. The amount of uranium in the gypsum pond is estimated to be 300–600 tonnes. On November 4, 2012, water from a gypsum waste water pond began to leak at the Talvivaara mine after the bottom of pond gave way. According to current estimates, about 0.1–0.6 ton of uranium was released into the environment. In the mining area, there are about 30–40 tonnes uranium in different kinds of waters. Uranium has been removed from contaminated water by lime

precipitation (neutralization). This precipitation containing uranium is temporarily stored in different basins in the mining area and in large geotubes.

Some new mining and milling activities involving NORM are foreseen to start in the near future. Considering the implementation of the new BSS directive, new developments on the regulatory control are envisaged, including the possibility to require formal licensing of such NORM practices.

There are also some legacy mining sites from past practices involving NORM of non-nuclear origin. In 1961–1972 lead was mined and processed in Korsnäs, on the West Coast of Finland. The amount of waste is 760000 tons. The average uranium and thorium concentrations of the waste are both estimated at 60 ppm. Currently there is no foreseen use for the area and the area is surrounded with a fence. Possible remedial action is considered when the current owner (Municipality of Korsnäs) decides on the possible future use of the area. Also about 36000 tons of milled ore remained at the mining area. It contains 120–360 ppm of uranium and 250–370 ppm of thorium. In 1997, the heaps of ore were remedied by covering them with a one-meter thick layer of soil.

At the Vihanti Zinc mine, where mining activities ended in 1992, the wastes contain uranium 400 Bq/kg (30 ppm) on an average. The area has been covered with a thin layer of soil which, together with the increasing vegetation, prevents dusting and reduces slightly external gamma radiation.

### **3. Scrap metal industry**

All important users of scrap metal have installed fixed radiation monitors at the gates of their installations. STUK co-operates with the Customs and the metal industry in questions such as measurement arrangements and training of personnel. STUK also provides expert help in cases where exceptional radiation is detected.

On an average, about 1–2 sealed radioactive sources have been found annually among imported scrap metal. In case where the source is still unbroken it may be possible to identify the manufacturer's source identification number which allows investigations for identifying the owner by using regulatory's, supplier's and manufacturer's registers of sources and their deliveries. There have been cases where such investigations take place across the borders in co-operation with different Nordic authorities. Orphan sources, whose owner cannot be identified, are delivered to the State interim storage at Olkiluoto.

Not all radioactive sources among scrap can be detected in time. This applies especially to Am-241 sources due to its very weak gamma energy making its detection very challenging. For this reason, several radioactive sources containing Am-241 have been accidentally melted in Outokumpu Stainless Oy's steel foundry in Tornio - despite of all possible state-of-art detection technology in use. After melting, Am-241 can be easily detected in slag and dust. The first accidental melting was detected 2006 and since then the same has happened rather regularly almost yearly. In 2014, already two cases have occurred. Since 2010, radioactive waste arising from these occurrences (mainly Am-241 contaminated slag and dust) have been disposed in the vicinity of the foundry and covered in accordance with a plan approved in 2010.

In addition to actual radioactive sources, many other radioactive objects have been found. These include pieces of metal contaminated with NORM (typically surface contamination) or

containing artificial radionuclides. In addition to NORM, the most common radionuclides detected are Ra-226 (typically old devices where Ra-226 was used for luminance purposes), Co-60 (typically objects made of contaminated metal originating from some earlier melting of a Co-60 source) and Cs-137 (typically surface contamination in a piece of metal originating from some furnace burning peat or wood; origin of the Cs-137 is Chernobyl fallout). The overall accumulation of such objects can be estimated at a few m<sup>3</sup> per year. The objects containing artificial radionuclides are generally delivered to the State interim storage at Olkiluoto. Some of the objects containing surface contamination (NORM or Cs-137) are cleaned on site. To some extent some of the objects have been disposed in industrial waste sites based on STUK's acceptance and the final approval of Environmental Authorities regulating the site as a whole.

#### **4. Uses of radioactive sources in some consumer products**

A specific issue of radioactive waste arises from disused smoke detectors. There are currently over 3 million detectors in use, each containing about 40 kBq of Am-241. The disposal of an individual detector into normal municipal waste was earlier considered, from the radiological point of view, as the optimum waste management option. However, the Council Directive 2002/96/EC of 27 January 2003 defines disused smoke detectors as waste electronic equipment subject to recycling requirements. Nowadays, a private entrepreneur takes care of removing the radiation sources from recycled smoke detectors and hands them over to an installation licensed to receive, condition and transfer radioactive waste to a central storage operated by the Radiation and Nuclear Safety Authority (STUK).

#### **5. Enhanced Nordic collaboration**

Possible areas where enhanced Nordic collaboration might be useful (exchange of experiences and/or to seek possibilities for common Nordic approaches):

- Policies and strategies for dealing with spent sealed sources; commitment to return to the manufacturer and financial guarantee arrangements; how to deal with legacy sources for which returning to the manufacturer is no longer possible.
- Policies and strategies for dealing with radioactive waste arising from scrap metal industry (radioactive objects found within scrap metal).
- Policies and strategies for the management of various types of NORM (Naturally Occurring Radioactive Material) waste, including recycling to construction materials and final disposal options.



## GEISLAVARNIR RÍKISINS ICELANDIC RADIATION SAFETY AUTHORITY

5 June 2015

### **Appendix A.3.**

#### **Radioactive waste in Iceland – an overview.**

Radioactive waste in Iceland originates mainly from the use of radioactive sources in medicine but also from uses in research, education and industry. The very low activity and volume of radioactive waste produced in Iceland does not justify a national final waste depository. As of 1 October 2014 there were 36 registered users (licensees) of sealed sources in Iceland and 5 registered users of unsealed sources, mostly laboratories doing medical or biological research using very low activities.

The first legislation in Iceland on radiation protection was passed in 1962 and has been revised periodically. The legislation covers all relevant radiological safety issues. The latest major revision took place in 2002: Act 44/2002, with the aim of harmonizing the Icelandic legislation in the field of radiation protection and its implementation with the Directives of the European Union in the field of radiation protection and their implementation. Iceland is not a member of the European Union and the Directives of the European Union in the field of radiation protection have no legal bearing in Iceland.

#### ***Radioactive waste management policy***

Radioactive waste is regulated within the framework of the Act on Radiation Protection and regulations on radiation protection based on the Act. These are Regulation 809/2003 on radiation protection in use of open sources and Regulation 811/2003 on radiation protection in use of sealed sources.

Radioactive waste management policy in Iceland is based on the practical needs of the country. The very low activity and volume of radioactive waste does not justify a national final waste depository. Therefore the requirement is that disused sealed sources be returned to the supplier or to a foreign waste management facility that the supplier has an agreement with, or disposed of in another legal way accepted by the Regulatory Authority unless they can be stored under secure conditions until decayed. Short lived radionuclides mainly from medical applications are stored for decay at the licensees premises until they can be released into the sewage system.

## Inventories

Disused sources are stored, under the control of the Regulatory Authority, on the users' premises until decayed or shipped to a foreign radioactive waste management facility. The Regulatory Authority takes care of disused sealed sources for which safe management may not be guaranteed. This consists mainly of smoke detectors that contain trace amounts of Am-241, small amounts of thorium or uranium salts as well as other sources of low activity and volume.

An overview of disused sealed sources in interim storage is given in appendix 1. The following users have a limited set of sources in an interim storage:

- (i) Landspítali - The National University Hospital of Iceland (Radium needles, total activity 19.2 GBq; see Annex 1)
- (ii) The Icelandic Radiation Safety Authority stores a few low-activity sources for licensed owners, which have not been able to demonstrate the need for use of the source, adequate storage conditions or having a qualified contact person. Most of these sources are disused sources from schools, where experiments involving radioactivity have been removed from the curriculum. In addition, the Regulatory Authority stores a few low-activity sources that previously were stored at the University of Iceland.

Exemptions from the requirements of the Icelandic Act on Radiation Protection with respect to specific and total activity of material handled are covered under Article 7 of the Act and corresponding guidelines, GR-04:01. These are based on the Schedule to and text of Annex I of EU Council Directive 96/29 Euratom of 13 May 1996. The directive has no legal standing in Iceland, but it was used as a reference to ensure consistency in requirements with EU countries.

The guidelines are in the process of review and the revised guidelines for exemption will be based on Annex VII of the new EU BSS.

Buyers of sealed sources are required to ensure that an imported source can be returned after use before a licence is granted to import and use a radioactive sealed source.

**The inventories of the radioactive waste stored on 1 October 2014 on the Regulatory Authority's premises and on the users' premises are listed in Annex 1 and an estimate of liquid releases from medical and laboratory use to the sea is made in Annex 2.**

Geislavarnir operate a comprehensive database of all radioactive sealed sources in Iceland.

## Legislative and Regulatory system

The legislation in Iceland for radiation protection, including radioactive waste, was established in 1962 and has been revised periodically. The legislation covers all



relevant radiological safety issues. The latest major revision took place in 2002, Act 44/2002 on radiation protection, with the aim of harmonizing the Icelandic legislation in the field of radiation protection and its implementation with the Directives of the European Union in the field of radiation protection and their implementation. Iceland is not a member of the European Union and the Directives of the European Union in the field of radiation protection have no legal bearing in Iceland.

The Regulatory Authority and the competent authority is the Icelandic Radiation Safety Authority which is under the auspices of the Minister of Health. The Regulatory Authority's role is to implement safety measures against radiation from radioactive substances and radiological equipment. The Regulatory Authority in its present form was established under the Act on Radiation Protection of 1985.

The Icelandic Radiation Safety Authority has a total staff of currently 10 persons, Most of which hold a higher University degree.

Details regarding regulation of radioactive waste are found in the relevant regulations and further developed by the Regulatory Authority through guidelines and requirements in licences.

Recent changes in the legislation addressing radioactive waste are additions to Article 12 that came in force on 1 January 2014 stating that the licensee is responsible for the storage, handling and disposal of radioactive substances and radioactive waste and that use of radioactive substances shall be in such a way as to generate as little radioactive waste as possible. Furthermore each licensee is required to report to the Authority yearly on the amount of radioactive waste that his practice generates. The minister implements in a regulation further provisions regarding classification, storage, handling and disposal of radioactive substances and radioactive waste.

The production, import, ownership, use, storage, delivery or disposal of radioactive substances, whether pure, mixed with other substances or installed in equipment, are subject to licensing by the Icelandic Radiation Safety Authority. The granting of licences is subject to conditions set out by the Regulatory Authority including provisions governing the handling of radioactive substances at the end of their use.

A licence is not required in respect of radioactive substances if their total content or concentration per mass unit is below the exemption limits as determined by the Icelandic Radiation Safety Authority according to Article 7 of the Act on Radiation Protection and corresponding guidelines GR04-01. The exemptions limits are based on the Schedule to and text of Annex 1 of the EU Council Directive 96/29 Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general population against the dangers arising from ionising radiation.

The guidelines are in the process of review and the revised guidelines for exemption will be based on Annex VII of the new EU BSS.

## Responsibilities of the licence holder.

The prime responsibility for the safe management of radioactive sources including radioactive waste management rests with the licensee according to the Act on Radiation Protection. This includes the responsibility to ensure that disused sealed sources are handled in a safe manner and returned to the manufacturer/supplier or disposed of in another legal way accepted by the Regulatory Authority. According to paragraph 12 of the Act, *the storage and disposal of radioactive substances shall always take place in accordance with the rules set by the Icelandic Radiation Safety Authority. The same applies to other waste, equipment or packaging which contains or is contaminated by radioactive substances.* The paragraph also states that *the Icelandic Radiation Safety Authority shall be notified when an instrument or equipment capable of producing ionising radiation is finally taken out of use. For as long as equipment contains radioactive substances or is capable of producing ionising radiation, it shall be kept in safe storage, and shall be safeguarded in accordance with the rules established by the Minister pursuant to Section 10, paragraph 4. The Radiation Safety Authority is authorised to demand the disposal or removal of radioactive substances and radiological equipment no longer in use. If the Authority's demands on disposal or removal are not met within a specified deadline, the Institute may carry out such actions at the owner's expense.* If the licence holder is in financial difficulties or out of business then the authority may take responsibility for safe disposal of the source.

All who have radioactive sources in interim storage hold a licence to own and use such sources and are subject to the terms of the Icelandic radiation protection Act, relevant regulations and regular inspections. This includes keeping the sources in a safe and secure storage, assuring that the doses to workers and the public are below the limits given in regulation (which is consistent with the recommendations of the ICRP and EU directives). Furthermore the principle of ALARA must be applied (paragraph 13).

Releases from laboratories must be as low as reasonably achievable and within the limits set in regulation 809/2003 on radiation protection in the use of open sources (this is based on publication *Application in the Nordic countries of International Radioactive Waste Recommendations*<sup>1</sup> and requires the total amount in a single release through a given route of disposal by a licensed user to be no more than 2.5 ALI and the total monthly release to be less than 25 ALI<sup>2</sup>). Since the laboratories apply the ALARA principle and store waste for decay whenever possible, the actual releases have in practice been far below these limits by all laboratories. The only exception is the medical use of radionuclides, for which the limits above do not apply.

Each laboratory using radionuclides is required to report amounts of radionuclides purchased each year, this is checked against corresponding information from importers. Additional information is obtained concerning the use in medical establishments administering radiopharmaceuticals. The largest releases from medical use in Iceland are from the radioiodine thyroid ablation treatments. In 2013 the total amount of I-131 in capsules for treatment was 83 GBq and 44.4 GBq in liquid form.

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<sup>1</sup> Published jointly by the Nordic radiation protection authorities in 1986

<sup>2</sup> Finland also uses the same system of limitation in the *STUK Guide ST 6.2 Radioactive Wastes and Discharges* (1999).

## **Safety of Radioactive Waste Management**

All those who have a licence from the Regulatory Authority to own and use radioactive substances are required to justify their use and thus keep their stock to the minimum necessary. The licensed user is responsible for that all those who handle waste do it according to accepted procedures, which have to be based on accepted practices within radiation protection and in accordance with the Icelandic Act and regulations on radiation protection. Every user is required to have an appropriate quality system. Regular inspections by the Authority include checking the records of radionuclide use and waste generation. Where appropriate (e.g. in medical use of radionuclides), the licensed user is responsible for that radiation safety issues are integrated with other safety issues that need to be taken into account (e.g. biological and chemical).

The Regulatory Authority has taken over a few low activity sources for long term storage i.e. sources used for teaching and smoke detectors. These sources are kept in locked safes in a storage room at the Authority and are subject to the same requirements as other sources in storage elsewhere. The storage of these sources is subject to internal and external audit as a part of the Authority's ISO 9001:2008 certified quality system.

## **Disused Sealed Sources**

The Ministry of Health and Social Security has issued Regulation No. 811 of 20 October 2003 *on radiation protection in use of sealed sources*. The Radiation Protection Act of 2002 and this regulation ensure that possession, storage and disposal of disused sealed sources take place in a safe manner. It is the responsibility of the license holder to ensure that disused sealed sources are handled in a safe manner and returned to the manufacturer/supplier or disposed of in another legal way. All facilities where sealed sources are used or stored are inspected by the Regulatory Authority every 2 – 4 years in order to ensure that the use and storage of these sources is in accordance with the legislative framework and requirements in the licenses.

No manufacturing or remanufacturing of sealed sources takes place in Iceland.

The Regulatory Authority encourages licensees to dispose of their disused sealed sources by sending them back to the supplier and it has provided some assistance where needed. The close contact and co-operation with users has resulted in that all disposal has been reported and done in consultation with the Regulatory Authority, not only the disposal of high activity sources.

In case of orphan sources, the procedure for the Regulatory Authority is to take control of the source, to ensure its safe storage and find the owner if possible. A legal action may be taken towards the owner if circumstances warrant such an action. Orphan sources are very rarely identified in Iceland. There have only been very few cases over the last years, and in all cases, involving low activity sealed sources. In all cases these have been old sources ( legacy sources ) in storage that the owner has forgotten and are found during an inspection of sources still in use.

In Iceland disused sources have the same legal status as sources in active use. They are subject to the same requirements concerning a safe and secure storage and they are also subject to regular inspections as sources in active use. Additionally, once sources are taken out of active use the licensee is required to notify the Regulatory Authority. The Regulatory Authority is authorized to demand the disposal of a radioactive source no longer in use or no longer in safe and secure storage as estimated by the Authority. If the demands are not met within a specified deadline the Regulatory Authority may carry this out at the licensee's expense. The only old disused radioactive sources of relevance are at The University Hospital where old radium needles no longer in active use are kept in a special secure basement storage.

The Regulatory Authority has taken into use a sensitive mobile gamma spectrometric system that can be mounted in vehicles of most kinds and is capable of detecting weak gamma emitting sources. This greatly enhances the capability of the authority to find orphan sources. The Directorate of Customs and the Coast Guard also have identical systems that are being used for routine surveys and can be deployed for special use, e.g. should the need arise for a search for an orphan source. These systems are complemented by backpack systems with gamma and neutron detection capabilities, for search in less accessible and indoor locations.

Long term storage and disposal of old disused radioactive sources can be a challenge, especially for non-nuclear countries with very limited quantities of radioactive waste. Such sources can often not be returned to the manufacturer, and if a cost effective way of disposal is not found there is a risk that the sources are to be kept indefinitely at the place of last usage and without a defined procedure for final disposal.

## **Annex 1**

### **Disused sealed radioactive sources in Iceland as of 1 October 2014**

These are sealed sources kept in storage by licensed owners i.e. the University Hospital and subjected to regular inspections by the Icelandic Radiation Safety Authority.

The activity given is the nominal activity. For each radionuclide (apart from Ra-226) there is one or a couple of sources that contribute most to the total activity, with the sum of all the other sources being small in comparison. The activities of these dominant sources are given for each radionuclide.

#### **Co-60**

2 sources (4 in 2011)

Total nominal activity: 8.5 GBq

Largest sources: 6.9 GBq (February 1980) and 1.55 GBq (July 1991)

#### **Am-241**

2 sources (6 in 2011)

Total nominal activity: 12.8 GBq

Largest sources: 11 GBq (December 1980) and 1.8 GBq (January 1986)

#### **Am-241/Be**

3 sources (5 in 2011)

Total nominal activity: 12.5 GBq (19.9 GBq in 2011)

Largest sources: 11 GBq (November 1982) and 1.5 GBq (December 2004)

#### **Ra-226 (needles) (unchanged from previous reports)**

A total of 37 needles are stored at the University Hospital of Iceland

Their nominal activity ranges from 0.09 to 1.85 GBq.

Total nominal activity: 18.9 GBq (January 1967)

#### **Cs-137**

6 sources (7 in 2011, 18 in 2009)

Total nominal activity: 11.1 GBq (11.4 GBq in 2011)

Largest sources: 2 x 4.6 GBq (January 1977)

## **Annex 2:**

### **Estimate of liquid releases from medical and laboratory use to the sea**

The usage by research laboratories has continued to decline. The dominant factor is the releases due to the treatment of relatively few patients. These releases can vary from year to year.

The assessment is based on the conservative assumption that all the amount of the radionuclides used is discharged to the sea. This is a gross overestimate, but as the discharge from patients is subject to many uncertain factors, this method at least provides a consistent framework for comparison. The same method of assessment was used in the reporting to the 3rd Review Meeting.

#### **Medical sector**

##### **Discharge of Tc-99**

Based on the amount of Tc-99 discharged on the assumption that 100% of the amount of Tc-99m administered has decayed to Tc-99 and that it is all discharged. The actual number is highly dependent on the use of the Mo-99 generator, but the amount discharged is low: **5 kBq**

##### **Discharge of I-131**

In 2013 the total amount of I-131 administered was 128 GBq. Based on 100% discharge of the administered dose for I-131 Ablation Therapy and 30% of the administered dose for I-131 Thyrotoxicosis treatment – for out-patients, a total discharge of 106.5 GBq is estimated.

##### **Other radionuclides (small amounts, conservative estimate based on the reported use):**

Ga-67	123 MBq
H-3	5 MBq
I-123	12.580 MBq
In-111	1.830 MBq
P-32	19 MBq

#### **Research laboratories**

Research laboratories in Iceland (outside the medical field) use very limited amount of radionuclides and it seems to be declining. No laboratory used more than 19 MBq of any radionuclide and in most cases storing for decay has been a standard procedure for short lived radionuclides

## Appendix A.4.

### Non-nuclear radioactive waste in Norway – an overview

Jelena Mrdakovic Popic

Norwegian Radiation Protection Authority

#### 1. Introduction

In world scale, Norway produces low quantities of radioactive waste since there is two nuclear research reactors, but no commercial nuclear energy production in country. However, the non-nuclear radioactive waste is regulated and managed according to the international standards.

The Norwegian *Pollution Control Act* from 1981 came into force on radioactive pollution and radioactive waste from January 1<sup>st</sup> 2011. With new *Regulations*, a kind of holistic approach to the protection of human health and environment has been created regarding regulatory practice in Norway. All radioactive waste in Norway is now regulated alongside hazardous waste in an integrated, ecosystem based approach; for instance radioactive waste has since then been declared in joint declaration scheme with hazardous waste.

The *Act on Radiation Protection and Use of Radiation* constitutes the legal basis for regulating the use of ionizing and non-ionizing radiation and radiation protection requirements, both in the medical/ non-medical fields and contingency planning. The Act applies to any manufacture, import, export, transport, transfer, possession, installation, use and handling of radiation sources. *Radiation protection regulations* establish requirements on authorizations, notifications, internal control, competence, safety equipment, emergency preparedness etc. for users of radiation sources.

Furthermore, certain recommendations and agreements of the international conventions (OSPAR, London, IAEA Joint convention) are implemented in regulations. In addition, the Norwegian Radiation Protection Authority (NRPA) has developed guidance documents for the different areas of radioactive waste management and application of radioactive sources.

Non-nuclear radioactive waste is generated mainly from the following practices and activities:

- Use of radioactive sources in health sector
- Use of radioactive sources in research institutes
- Petroleum industry
- NORM mining and other NORM processing activities
- Use of radioactive sources in some consumer products
- Use of measurement gauges

Short description of waste generated within each of these categories is given in following sections. **In 2014, it was registered 13 128 tonnes of radioactive waste in Norway. Approximately 11 390 tonnes (ca 86.7 %) were radioactive stones, mainly alum shale masses.**

## **2. Sealed radioactive sources**

Sealed radioactive sources are used in Norway in various applications in medicine, industry, transportation, construction, geology, mining and research. The activity of source is variable from kBq to TBq. Norwegian Radiation Protection Authority has an electronic, net-based registration procedure for sealed radioactive sources. This national source register is a combined electronic register and notification system for users of radiation sources. According to database, around 3500 sealed sources are registered, majority in IAEA category 4 and 5. The installation and use of industrial sources normally requires only that NRPA is formally notified of the planned activity. If, however, the activity of the radioactive source exceeds a certain value, then the enterprise that will be utilising the source must be approved (for the most common sources, such as Co-60, Cs-137, Am-241 and Kr-85, approval is required at activity levels of 10 GBq. For Promethium-147, the level is 10 TBq).

### **2. 1. Orphan sources**

In Norway there are approximately 3-5 incidents (in average) with lost radioactive sources every year (although in recent years number of these kind of events decreased). The orphan sources are often old industrial gauges taken out of use. If an orphan source is found, the normal procedure is that the NRPA attempts to find the owner, order a secure and safe waste management of the orphaned source regardless of costs, and, if relevant, to search for other orphaned sources. At the Storskog border point (Norway–Russia) a monitoring portal has been in operation for almost ten years. The customs have portable measuring equipment at their stations across the country. Most private companies dealing with scrap metal or other businesses that might receive contaminated waste have monitoring portals or handhelds. This prevents radioactive sources from being sent into shredder facilities or being melted down in foundries.

### **2.2. Management of disused sealed sources**

Undertakings that procure, use or dispose sealed radioactive radiation sources have a duty to assure that a return scheme exists in the country of origin and to return the disused sources to the producer. Distributors of radioactive sources are required to have authorization from the NRPA. When the NRPA issues authorizations for companies to buy, sell or use sealed sources, it is with the requirement that disused sources are to be returned to the manufacturer. However, if no viable return options are available, the undertakings have to ensure safe handling and deliverance of these sources to a Norwegian waste management facility. The Combined Disposal and Storage facility for low and intermediate-level waste of Institute for Energy Technology (IFE) in Himdalen has licence from NRPA to store this kind of waste. The capacity of this disposal and storage site is high enough to receive these kinds of sources until the end of planned working period in 2030 (assuming unchanged current plans for waste deposition).

## **3. Radioactive waste from health-care activities**

Radioactive substances (mainly Tc-99m, I-131, I-123, Lu-177, F-18, Cr-51, C-14, Y-90, Ra-223) are used in medical diagnostics and treatment in 24 authorized medical laboratories in 18 hospitals in country. NRPA gives permits to hospitals to release radioactive substances into a sewage system and air. In total, 4.58 TBq of radioactive waste is reported as discharged into the environment from hospitals in Norway in 2014;



contribution of Tc-99m, I-131 and F-18 is about 98%. The estimated radioactive waste released into the sewage system and air in Norway is given in Figures 1 and 2.

Further, medical laboratories may temporarily (less than one year) store some of their short-lived radioactive wastes at dedicated storage facilities until they have decayed below the limits set for radioactive waste in proper regulations. After that, decayed radioactive waste can be managed as non-radioactive waste. Medical laboratories can also temporarily store liquid radioactive waste until the activity in the waste are negligible. The liquid waste may then be disposed of into a sewage system if applicable and legal after other regulations, delivered to a disposal site or an incineration plant.

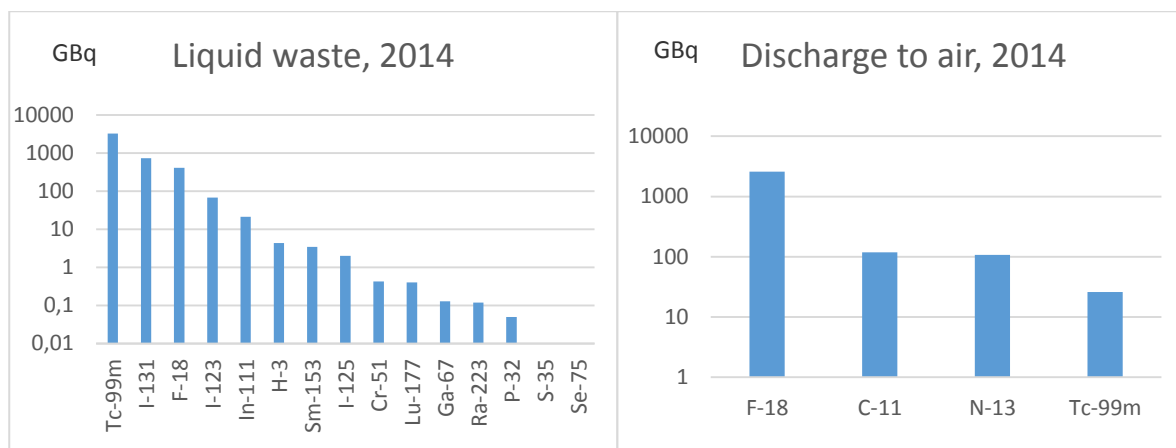


Figure 1. Radionuclides released into the sewage system in Norway in 2014.

Hospitals and other industries, which have a permit to discharge radionuclides or handle radioactive waste, have a duty to send annual reports of radioactivity released into the environment and radioactive waste sent to disposal sites to NRPA. In 2014, 4.56 tonnes radioactive waste was sent to disposal from hospitals in Norway.

#### 4. Radioactive waste from research activities

According to national register, open radioactive sources are used in 15 research laboratories (universities, institutes). The most common radionuclides are H-3, C-14, I-125, P-31, Cr-51, S-35, P-33, Cs-134, Cs-137, Cd-109. Generated short lived radioactive waste is typically stored until decayed to values below the limits given in regulations and disposed as non-radioactive waste. Radioactive waste with long-lived radionuclides has to be sent to IFE treatment and storage facility in Himdalen. In 2014, 24.48 tonnes of radioactive waste was declared. The largest waste producer is IFE and most abundant radionuclides are H-3 and C-14.

#### 5. Petroleum industry

Radioactive waste from the Norwegian petroleum industry is produced during both operations and decommissioning. According to register, 76 oil and gas production platforms are currently in operation in Norway. Each year the petroleum industry generates quantities of produced water, scales, sludge, and loose material from production with high levels of Ra-226, Ra-228 and Pb-210 and their daughter products. In addition, there is contaminated equipment.

The radioactivity levels in produced waters are generally low, but the volumes are large. For instance, 156.4 million m<sup>3</sup> are discharged in 2011 to seawater or re-injected into deep wells. Content of Ra in

produced water can be 100-1000 higher than water backgrounds levels (e.g., 4-5 Bq/l for Ra-226 and 2-4 Bq/L for Ra-228). Current estimations of radioactivity discharge to the environment via produced water in 2014 are 402 GBq of Ra-226, 348 GBq of Ra-228 and 19 GBq of Pb-210.

Oil contaminated masses from offshore installations are routinely screened for radioactivity content. The NORM-contaminated waste and NORM-contaminated equipment is routinely received by onshore companies with licences from NRPA for handling of NORM. Wastes with activity concentrations below 1 Bq/g are classified as non-radioactive. Where activity concentrations are in the range of 1 to 10 Bq/g, disposal can be to the NOAH Langoya hazardous waste disposal facility. Wastes with an activity concentration greater than 10 Bq/g are routed to the Stangeneset licensed disposal site for the disposal of NORM wastes. All petroleum industry waste in Norway is declared and, as such, each waste type is assigned a specific classification number.

About 350 tonnes of different types waste from petroleum industry were declared in 2014. An estimation of number of platforms to be decommissioned in period 2010-2020 is 32. It is further estimated that decommissioning of one big offshore installation would generate about 3 tonnes of radioactive waste (> 10 Bq/g) or in Norwegian case, 96 tonnes of radioactive waste if assume that all platforms to be decommissioned are big.

## **6. NORM waste (other than petroleum industry waste)**

According to waste declaration register, 31 537 and 11 390 tonnes of radioactive material in form of excavated rocks (stones) were declared in 2013 and 2014, respectively. NORM waste (other than petroleum waste) has been, up to June 2015, exclusively sent to disposal site NOAH. Recently, new disposal site Borge has got the licence to store NORM rock waste with potential for acid drainage. NORM in rocks with acid drainage potential (such as alum shale or black shale) is a big challenge for Norway due to large volumes of already excavated rocks (that potentially may be radioactive waste/or cause radioactive pollution), planned construction projects in alum shale areas (more large volume waste) and current lack of disposal sites. NORM waste is produced mainly in mining activities and process industries that use raw materials.

### **6.1. Mining activities**

Currently neither radioactive waste generation nor radioactive pollution have so far been registered in existing mines in operation in Norway. However, radioactive waste from legacy mines has given rise to problems such as elevated exposure of the public from external gamma radiation, Rn and groundwater contamination on several locations in Norway. *Søve mining site* in Telemark County in geologically specific NORM rich Fen area was in operation 1956-1963 for Nb production. After decommission, parts of the site were covered with sand in remediation actions, but measurements in last decade have shown high gamma dose rates (up to 20 µGy/h) and hot spots - U and Th enriched spots (2000 Bq/kg and 8500 Bq/kg, respectively). Rough estimation of the volume of waste to be removed is 2500 m<sup>3</sup> although exact volume is still unclear. The Ministry of trade, industry and fisheries is currently working (with NRPA guidance) on options for disposal of radioactive waste from *Søve mine*. *Oterstranda* mining site is located in Gildeskål municipality in Nordland County. The mining activity was based on extraction of Mo minerals from the ores. An initial flotation process was performed at the site. Approximately 90 000 tonnes of mining residuals were deposited on a beach in the close vicinity to the flotation plant. The maximal concentrations of U-238

and Ra-226 in solid residues from mining are up to 12000 and 10000 Bq/kg, respectively. Several summer cottages are located in the area and the residuals from the mining activities are being used as a public beach for sunbathing and swimming during the summer by the local population. The NRPA is currently working on this case.

## **6.2. Mineral processing industry**

*Titanium dioxide production* – radionuclides from U and Th series can be concentrated in process scale and in form of precipitations on vacuum filters (on filter clothes) and dust on electrostatic precipitators (ESP). In 2014 was 100 tonnes of ESP dust was traded. Specific and total content of Po-210 and Pb-210 was 12.31kBq/kg and 1231 MBq and 19.31kBq/kg and 1931 MBq, respectively.

*Phosphate production* – production of phosphate mineralizers and cement can generate radioactive discharge into the environment. Yara, European biggest fertilizer producer in Europe has two production sites in Norway (Porsgrunn and Glomfjord). NRPA gave the permit for discharge U-nat and Th-nat into the environment; 6.19 MBq and 0.45 MBq of U-nat and Th-nat, respectively, were discharged to the environment in 2014.

## **7. Radioactivity in consumer products**

### *Disused smoke detectors*

A specific issue of radioactive waste arises from disused ionisation chamber smoke detectors (ICSDs) containing Am-241. ICSD are part of waste electrical and electronic equipment (WEEE). According to the regulations, WEEE may be delivered free of charge to municipal waste treatment facilities or to distributors who sell similar products. Proper management of WEEE is a producer responsibility; importers and producers have set up take-back companies to manage WEEE in accordance with the regulations. After collection and sorting, ICSDs are dismantled manually at special facilities and radioactive waste from ICSDs is sent to IFE's Combined Disposal and Storage facility for low and intermediate-level waste in Himdalen. According to IFE's annual report, approx. 2 GBq of Am-241 from ICSDs was disposed of in 2014.

## **8. Issues for Nordic collaboration**

Further and more intense Nordic collaboration might be beneficial regarding following issues:

### **1. NORM waste in process industries in Nordic countries – overview of current status, legislation, comparison of practices and experiences (case study)**

- Overview of potentially new and existing NORM industries producing radioactive waste in Nordic countries – according to EU BSS
- Legislative requirements in different countries – overview
- Waste management and disposal requirements
- Monitoring programs – comparison of requirements regarding
  - Timescale for monitoring – institutional control

- Objectives – biota scale
  - Source monitoring or environmental monitoring (ecosystem based approach)
  - Sampling and methods requirements
  - Reporting of collected data
  - Case study
2. **NORM waste at legacy mining sites – comparison of legislative requirements, practices and experience exchange** with respect to
- EU BSS requirements
  - Environmental impact assessments
    - ✓ Protection objectives
    - ✓ Assessment endpoints and timeframes
    - ✓ Key pathways of NORM mobilization into the environment
    - ✓ Approaches to investigate multiple stressors in environmental media and to address effects in biota and humans
    - ✓ Risk characterization and criteria for site restoration/decontamination
  - Definition of criteria for future land use planning
  - Waste management and disposal options
3. **Orphan sources** – practices and experiences how to deal with legacy sources for which returning to the manufacturer is no longer possible- military sources for instance
4. **Thorium and uranium** as by-products in some industries.



## Appendix A.5.

# Overview of non-nuclear radioactive waste in Sweden

Erica Brewitz

06-06-2015

## The regulatory framework

All handling of radioactive waste and disused sealed sources is covered by the Radiation Protection Act (1988:220).

Detailed requirements on the handling of radioactive waste and disused sealed sources are found in regulations issued by SSM, see Annex 1. In addition to the regulations, SSM can also issue license conditions concerning the management of radioactive waste and disused sealed sources. Currently, the SSM regulatory framework is undergoing revision, as is the Radiation Protection Act.

The licensee is required to report to SSM when a disused sealed source is either returned to a manufacturer or supplier, or sent for disposal. Since one of the fundamental principles of the Swedish radioactive waste management system is that waste generated in Sweden shall be disposed of in Sweden, radioactive waste to be disposed of is sent to the only recognized radioactive waste management facility in Sweden, Studsvik Nuclear AB (SNAB), for treatment and storage before disposal.

## Management of radioactive waste

Laboratories that use unsealed sources with very short half-lives are permitted to store the radioactive waste until it has decayed sufficiently to allow for it to be handled as conventional waste. Decay storage of sealed radioactive sources occurs to a limited extent in medical services, research and industry. Laboratories in which unsealed sources are used, can release liquid radioactive materials when the activity levels of solutions are below the prescribed levels, to the municipal sewerage system or send solid radioactive materials for incineration at municipal facilities. SSM regulations also contain provisions on general clearance of radioactive material originating from all activities involving ionising radiation, including NORM. It is common for an agreement to be made already at the point of sale of a radiation source, on return of the disused sealed source to the supplier, or directly to the manufacturer abroad. Some manufacturers have developed methods enabling both reuse and recycling of disused sealed sources. Some waste management companies abroad also have approved methods for reusing and recycling disused sealed sources of radioactivity.

## Disposal

Non-nuclear radioactive waste that cannot decay, be released, cleared, reused or recycled must be taken care of by a waste management company approved by SSM, which there is only one of today: Studsvik Nuclear AB (SNAB). The radioactive waste generated by non-nuclear activities varies in terms of nuclide and activity composition and chemical and physical characteristics; however, as regards volumes, they are very small compared to the radioactive waste generated by nuclear activities. Sweden has no final disposal facilities designed specifically for non-nuclear radioactive waste. Instead, the Swedish Nuclear Fuel and Waste Management Company (SKB) has agreed to dispose of short-lived non-nuclear LILW in the SFR repository. At the same time SKB indicated that they might carry out planning and

dimensioning of the future waste facility SFL so as to encompass management of long-lived non-nuclear LILW. SNAB treats and conditions the waste and also takes on the responsibility for the waste. All radioactive waste is put in packaging and stored in SVAFO's rock cavern on the site pending disposal.

### **Orphan sources**

Licence holders are required to take all measures necessary so as not to allow for sealed sources to fall outside of regulatory control. Orphan sources are nevertheless found, quite often at scrap metal recycling facilities or in private households. If the licensee responsible cannot be identified, or the material is considered legacy radioactive waste, the State will provide financial resources for the management and disposal of the orphan source. This is made possible through a special governmental funding arrangement that allows SSM to cover the costs, up to a total of 2 million SEK per year in 2013 and 2014 for the management and disposal of orphan sources and legacy radioactive waste from past practices.

### **Gaps in the waste management system**

The existing system designed for management of nuclear waste and radioactive waste from Swedish nuclear power plants also deals with the non-nuclear radioactive waste. However, when it comes to certain categories of non-nuclear radioactive waste, a definitive treatment method and/or a solution for disposal have yet to become established. SNAB is not required to accept disused sealed sources or radioactive waste from non-nuclear applications. The company operates on a commercial basis and the management of non-nuclear radioactive waste may not always be of highest priority, which can lead to all sorts of problems, ultimately forcing non-nuclear facilities to store growing amounts of radioactive waste for longer periods of time. Examples of waste categories that SNAB is reluctant to, or refuses to, accept:

- Metallic uranium
- Metallic alloys such as magnesium-thorium does not meet the criteria for disposal in SFR or SFL
- Neutron sources
- Uranium and thorium chemicals consisting of acetates and nitrates
- Scrap metal with NORM
- Sealed sources with tritium
- Biological waste with C-14 and tritium

SNAB is presently reviewing some of these difficulties, the company has in its ownership neutron radiation sources, tritium radiation sources and metallic uranium. For these problematic waste fractions, the company is required to produce waste management plans. SNAB is currently working on preliminary studies for method development aspects of treatment and disposal of these waste fractions. The company expects to complete its preliminary studies by 31 December 2015.

## **Generation of radioactive waste**

### **Medicinal, industrial and research applications**

Sealed sources are used in nuclear medicine for diagnostics and treatment purposes. Sealed sources with high levels of activity are mainly used for radiation treatment. Another medical application is blood irradiation devices containing high-activity Cs-137 sources. Depleted uranium is used where radiation shielding is necessary, for example in radiation shields, radioactive cobalt sources and transport containers for radioactive sources.

Sealed radioactive sources are used in all kinds of industrial activities for different types of checking and quality control measures, analysis work and the like. The most common types of equipment are level, density, moisture,

surface weight and thickness gauges, and the like. Other types of sealed radioactive sources include eliminators, and EC detectors. Material screening can in certain cases also be performed using sealed radioactive sources..

Research is conducted at institutions of higher education, pharmaceutical companies and in other industries and can be carried out in both laboratory and outdoor environments. All types of radiation sources are used, even equipment designed in-house by the institute in cases where there is no possibility of purchasing a piece of equipment to meet the staff's needs. Radioactive sources, pieces of equipment and facilities can vary in size from very small to very large—in addition to their quantity. Tracer studies are carried out when analysing flows in biological, geological and technical systems.

There are currently two ongoing large-scale licensing reviews for research facilities in Lund: The MAX IV Laboratory, which is an accelerator facility at Lund University, and the ESS research facility, comprising a spallation neutron source to be located next to the MAX IV facility. According to the time schedule, the MAX IV Laboratory will be operational in 2015. European Spallation Source (ESS) is a pan-European research facility planned to be fully operational in 2025. The ESS research facility in particular will generate considerable quantities of radioactive waste compared to present quantities generated by non-nuclear activities.

### **Consumer products**

Examples of consumer products containing radioactive material include ionising smoke detectors, compasses with a tritium light source, bearing compasses, bearing binoculars and night vision devices. Other examples of consumer products containing radioactive material are those which are no longer manufactured but are still around in people's homes: glass and ceramic objects with uranium, timepieces with luminous radium paint, and radium emanators. A very large amount of ionizing smoke detectors have been sold in Sweden throughout the years, both for domestic and industrial use.

Sweden has around 1.2 million permanent residents whose water comes from their own wells. Depending on their place of residence and their type of well, they may have problems with excessive levels of NORM, iron, manganese or humus in their drinking water. Poor water quality is rectified by installing water filters, which in themselves do not contain radioactive material. On the other hand, there is a risk of these filters—depending on their design—developing residues of excessive NORM concentrations after several years of use.

### **Energy producers**

Energy producers that burn peat or wood fuel can give rise to concentrations of radionuclides in the resulting ash. In certain parts of Sweden, forest land is contaminated with Cs-137, which the trees absorb through their roots. The main problem areas are in southern and central Norrland. In some areas, peatland may have become enriched by NORM in the groundwater. Peat containing NORM basically occurs throughout Sweden. In certain areas, there is a risk of the upper layer of peat also being contaminated with Cs-137 due to fallout from the Chernobyl accident. Pit coal is used to some extent for producing energy. This means that it can generate considerable quantities of ash (including both bottom ash and fly ash captured in filters). All coal used in Sweden is imported and concentration of NORM (uranium and thorium) takes place in the burning process. The content in the ash is entirely dependent on the content in the coal burned.

### **Uranium prospecting**

Prospecting that gives rise to small quantities of drill cuttings containing uranium is not classified as a nuclear activity. It is considered to be an activity involving ionising radiation, which is regulated by the Radiation Protection Act. Presently, just under ten companies have licences for uranium prospecting. Uranium prospecting in Sweden from the early 1950s up until 1986 resulted in collection of a large quantity of samples of radioactive mineralisations. To the extent that these samples are still around, most of them are in storage as specimens and drill cores at the drill core archives of the Geological Survey of Sweden, located in Malå.

### **Processing industries and water treatment plants**

Facilities that do not primarily use radioactive material in their operations, but which process large quantities of water, for example in pulp mills and water treatment plants, may over the years build up a concentration of NORM residues inside pipe systems and water treatment filters.

### **Scrap metal related industries**

Steel mills and metal recycling companies risk receiving radioactive material with the scrap metal arriving to these facilities. The scrap metal might contain radioactivity due to several factors. Usually, the scrap metal has residues containing NORM. The scrap metal might also contain equipment or instruments having a radiation source that was used in industry, research or medical care for a large range of applications. The steel industry largely applies 'zero tolerance' regardless of whether or not the measured level of radioactivity is harmless. Large facilities today have portal radiation detectors. This means that the facilities are involuntary handlers of incoming radioactive material, which in many cases—usually when NORM is involved—leads to the material needing to be stored at the receiving facility. This is because Sweden has no definitive solution for management of NORM.

### **Recycling facilities and other companies that manage conventional waste**

Today's system enables private individuals to dispose of ionising smoke detectors at recycling facilities. However, there is also a risk of recycling facilities receiving other kinds of radioactive material unbeknownst to the employees. This could for instance involve chemicals containing uranium or thorium. In some cases, the radioactive material is first discovered during shipment to a metal recycling facility having a portal radiation detector. Even other companies managing conventional waste can be affected by radioactive material ending up in their systems.

### **Legacy waste from manufacture of phosphoric acid and calcium phosphate**

In the agricultural sector, phosphor is used in animal feed and as fertiliser. Phosphor is also a component of a wide range of products in the chemical industry. Phosphor is no longer manufactured in Sweden, though it used to take place at two sites over a long period of time. Manufacturing phosphor generates phosphogypsum as a byproduct. The radium present in the raw material in addition to some of the uranium, precipitates in the phosphogypsum; however, most of the uranium is dissolved in phosphoric acid. Phosphoric acid was manufactured at the Supra AB factory in Landskrona starting in the 1940s, and at Boliden Kemi in Helsingborg. Waste from manufacturing of phosphoric acid is stored in connection with the factories. Phosphogypsum waste from Supra AB's operations is deposited on Vindön, an artificial island located a few hundred metres outside Landskrona. The island is 32 hectares in size, with its highest point at 15 metres. The island consists almost entirely of phosphogypsum waste totalling 4 million cubic metres. There are additional waste sites containing byproducts outside Landskrona. Phosphogypsum waste from Boliden Kemi's manufacturing of phosphoric acid and calcium phosphate totals around 6 million cubic metres. The waste is at a waste storage site located just outside Helsingborg's city limits.

### **Legacy waste from excavation and burning of alum shale**

Alum shale was formerly excavated in some parts of Sweden, for instance at Kvarntorp in the 1950s and at Ranstad in the 1960s. The high content of uranium in the shale led to extraction of this element. Attempts were made in the 1920s to extract radium from uranium-rich anthracitic coal in Billingen. Burning of alum shale took place on a large scale in Sweden between the mid-1600s and the late 1970s for purposes such as burning limestone, manufacture of alum shale cement and alum shale-based lightweight concrete ('blue concrete') and manufacture of petroleum products. What above all remains from these legacy activities is a great number of deposits of the byproduct burnt alum shale, of which some exceed a half million cubic metres in size. The largest one is the Kvarntorpshögen deposit, which is 40 million cubic metres in size.



### Legacy waste from iron ore extraction

No known uranium mineralisations occur at any Swedish mines in operation today. On the other hand, there are deposits of spoil (waste rock having too low iron content to be classified as iron ore) at closed down mines that were sites of iron ore or siliceous iron ore extraction. In cases where the ores are associated with uranium mineralisation, this is usually only represented in a small proportion of the spoil and then most often individual pieces of waste rock consisting of uranium mineralisations. The mines in question are often small, or relatively small, and as mentioned, ore extraction ceased a long time ago. The fact that these mines are small also means that the volumes of spoil are limited. Another byproduct of iron production is represented by the slag deposits located nearby closed down blast furnaces that once melted uranium-rich iron ore.

### Demolition waste containing 'blue concrete'

Lightweight concrete produced using uranium-rich alum shale—also called 'blue concrete'—was used as a building material in housing and other buildings from the late 1920s up until 1975. An estimated 300,000 buildings around Sweden contain alum shale-based lightweight concrete. In pace with these buildings and houses being demolished, the blue concrete enters the waste management system. This kind of lightweight concrete contains uranium and radium-226 in different concentrations and emits radon gas and gamma radiation. Waste from demolished buildings containing alum shale-based lightweight concrete is not suitable for reuse as building materials or as fill material under buildings.

### Amounts of radioactive waste for geological disposal

SNAB receives approximately 250 disused sealed sources on a yearly basis, to which can be added approximately 130,000 disused smoke detectors and a number of radiation sources from already dismantled smoke detectors. After treatment, the disused sealed sources are stored by SVAFO, pending disposal in either the disposal facility for short-lived low and intermediate level waste, SFR, or the disposal facility for long-lived low and intermediate level waste, SFL. The table below shows the quantities of non-nuclear radioactive waste sent by SNAB for disposal in the SFR repository, the quantities stored at Studsvik awaiting disposal in SFR and SFL, as well as the annual waste quantities generated exceeding this, as at 31 December 2012.

Waste fractions based on final disposal solution	Volumes in SFR (m <sup>3</sup> )	Volumes in SFL (m <sup>3</sup> )
Already sent to SFR	93	
Stored at Studsvik, planned repository: SFR	66–81	
Generated annually, planned repository: SFR	3.5–5.6	
Stored at Studsvik, planned repository: SFL		56
Generated annually, planned repository: SFL		1.4

SNAB has to date sent a total of 93 m<sup>3</sup> of non-nuclear radioactive waste for disposal in the SFR repository. The waste was received by SNAB from 1 July 1991 to 31 December 2005, and handled jointly with other nuclear waste. This waste consists of ash and non-combustible waste embedded in 200-litre concrete barrels. Out of the discarded radiation sources and other non-nuclear radioactive waste currently received by SNAB, the company plans to only dispose of radiation sources from smoke detectors from domestic use in the SFR repository. Each year, SNAB receives around 130,000 smoke detectors. SNAB is also planning to have its own operational waste, corresponding to 0.2 m<sup>3</sup> per year, disposed of in the SFR repository. The 56 m<sup>3</sup> waste destined for SFL, consists of radiation sources and various other kinds of radioactive waste, and has to some extent been conditioned.

SNAB also receives radiation sources containing Krypton-85. The intention is recycling of this gas. These radiation sources are shipped off as part of campaigns for recycling purposes abroad.

## Residual products containing NORM

A number of shut down operations have given rise to large deposits of residual products containing NORM. This legacy waste occurs throughout Sweden, see the table below.

Material	Estimated quantities and occurrence
Burnt alum shale (uranium + daughter nuclides, 2.5–5 kBq/kg)	Totalling millions of tonnes, often in great heaps. Skåne, Öland, Småland, Östergötland, Närke, Västergötland and Lidingö. The Kvarntorpshögen heap is the largest deposit.
Phosphogypsum (uranium + daughter nuclides, 0.6–2.5 kBq/kg)	Totalling millions of tonnes, of which the largest heap is located on the island of Vindön (the “Gypsum island”) just outside Landskrona.
Iron ore spoil heaps (uranium + daughter nuclides, 2.5–12 kBq/kg)	Totalling hundreds of tonnes. With a few exceptions, these heaps of spoil are mainly located in Bergslagen in connection with closed down iron ore mines. The heaps of spoil contain rocks with uranium mineralisation.
Iron ore slag (uranium + daughter nuclides, 2–10 kBq/kg)	Totalling a few hundred tonnes in slag heaps at a couple of closed down blast furnaces where uranium-rich iron ore was melted. Well-known from Närke. Slag has also been used as a filler and building material.

Today’s activities and operations also generate residual products containing NORM. Although alum shale-based lightweight concrete (‘blue concrete’) is no longer manufactured, some 300,000 buildings throughout Sweden still contain this material. In pace with these buildings being demolished, this gives rise to thousands of cubic metres of demolition rubble per year. This waste contains uranium with daughter nuclides (0.5–3.5 kBq/kg).

Peat containing NORM basically occurs throughout Sweden. Depending on the activity concentration, the ash can either be reused or need to be disposed of. Around 30,000 tonnes of peat ash are generated each year. This ash is mainly transported to facilities for use as a filler material. Peat ash also contains Cs-137 from fallout. Around one million tonnes of coal ash are disposed of each year. This context also includes burning of wood fuel, though this is ash containing Cs-137, not NORM. Approximately 100,000 tonnes of wood fuel ash are generated each year, of which less than 10 % is disposed of. Ash that can be reused is for instance used for geotechnical construction purposes.

The scrap metal recycling industry is presently storing scrap metal that is contaminated with NORM (as scale). The contaminated system components are stored at the facility of discovery, pending a management solution. The activity concentration of these residues shows great variations. The volume of contaminated residue in relation to the volume of metal is negligible. The industry has estimated that 60–80 tonnes of contaminated metal scrap is stored today, and that only a few tonnes of NORM contaminated metal are added per year.

## Future waste quantities

The planned operations at the ESS facility in Lund will generate substantial quantities of non-nuclear radioactive waste requiring disposal, in relation to the present quantities generated. European Spallation Source’s preliminary estimates show that the total quantities of radioactive waste from operations and decommissioning requiring geological disposal may be equivalent to approximately 15 % of the planned space of SKB’s disposal facilities SFR and SFL.

## Financial aspects

Parties conducting activities involving ionising radiation, and whose operations generate radioactive waste, have a liability, including financially, to ensure that the waste is managed in a way ensuring radiation safety, including disposal if needed. Consequently, this responsibility applies to all activities and practices involving ionising radiation: in medical services, industry, the agricultural sector, research, education and training programmes, etc., regardless of whether or not the operation requires a licence under the Radiation Protection Act.

## **The state bears the cost of disposal in some cases**

Parties with radioactive material to be managed as radioactive waste have only one entity in Sweden to turn to: SNAB. The fee payable to SNAB is to cover treatment, conditioning, storage, and in some cases, disposal of this waste. In the 1980s, the Swedish Government agreed to compensate SNAB by a one-off expenditure amounting to approximately SEK 54 million. This amount was intended to cover areas such as future costs for disposal of non-nuclear radioactive waste in SFR. This implies that owners of non-nuclear radioactive waste, which may be disposed of in the SFR repository, only need to pay for Studsvik's management of the waste. The costs for transport to SFR and disposal in this repository have already been borne by the state. However, owners of non-nuclear radioactive waste assessed as requiring disposal in SFL must pay a charge for SNAB's present waste handling: for extended storage of the waste, possible future conditioning, and transport to and disposal in SFL.

## **Financing management of high-activity sealed radioactive sources**

Owners of high-activity sealed radioactive sources must already when applying for permission, demonstrate that they are capable of financing its future management if the cost exceeds SEK 300,000. In this case, the licensee must be able to provide a financial guarantee. This financial guarantee may vary in form depending on the applicant. When the applicant is part of a public undertaking, accounting for the financial guarantee may be as a signed affirmation about funds being available to cover the entire cost of managing the disused sealed source. When the applicant is part of a commercial undertaking, accounting for the financial guarantee may be as a bank guarantee or in the form of a blocked account; in either case with a Swedish bank.

## **Possible Nordic collaboration**

Areas of interest are where we experience problems, such as treatment methods/final disposal solutions for e.g. various types of NORM, metallic uranium and metallic alloys (magnesium-thorium), uranium and thorium acetates and nitrates. Sweden also has a large number of smoke detectors that need to be managed, and the question is whether the current solution of final disposal of all the Am-241 sources is such a great idea or if reuse and recycling options would be something to look closer into.

## **Annex 1. SSM Regulations**

- Regulations on the Control of High Activity Sealed Radioactive Sources (SSMFS 2008:9) stipulate that high activity sources for which no further use is foreseen must be sent either to the supplier, to the manufacturer or to an approved facility for waste management within six months. The holder must notify SSM, which maintains a register.
- Regulations on Import, Export and Reporting on Radioactive Substances (SSMFS 2008:10) stipulate that in order to import or export disused sealed sources, a licence is needed and the import/export must be reported to the competent authorities.
- Regulations on Accelerators and Sealed Sources (SSMFS 2008:27) stipulate that the licence holder shall ensure that an up-to-date and documented plan exists for decommissioning of the facility. The plan shall include an analysis of the resources needed to take care of all radioactive substances and radioactive demolition waste in a safe way from a radiation protection point of view.
- Regulations on Radiation Therapy (SSMFS 2008:33) stipulate that in the case of the purchase of radioactive sources, or equipment which contains such sources, a plan shall be drawn up for the future handling of radioactive waste.
- Regulations on the Use of Equipment in Industry Containing Sealed Sources or X-Ray Tubes (SSMFS 2008:40) stipulate that equipment containing a radioactive source for which no further use is foreseen shall be sent to a radioactive waste management facility within six months.
- Regulations on Smoke Detectors for Industrial Use Containing Radioactive Sources (SSMFS 2008:44) stipulate that the disused units should be taken care of as radioactive waste and returned to the supplier or manufacturer.
- Regulations on Smoke Detectors for Domestic Use Containing Radioactive Sources (SSMFS 2008:47) stipulate that the units are to be collected and sent for dismantling.
- Regulations on Radioactive Waste Not Associated with Nuclear Energy (SSMFS 2010:2) apply to the handling of solid and liquid wastes from medical care, laboratories and scientific applications.
- Regulations and general advice concerning clearance of materials, rooms, buildings and land in practices involving ionising radiation (SSMFS 2011:2) contain provisions on the clearance of materials, rooms, buildings and land from activities involving ionising radiation.
- Regulations and general advice on naturally occurring radioactive material (SSMFS 2011:4) contains provisions on clearance of naturally occurring radioactive material. These provisions cover building materials, water treatment filters from private households and residues containing naturally occurring radioactive material.

## **Appendix B: National presentation slides presented at the meeting**

B.1. Denmark - Management of radioactive waste of non nuclear origin (David Garf Ulfbeck, National Institute of Radiation Protection, Denmark)

B.2. Finland: overview of non-nuclear radioactive waste issues (Mika Markkanen, STUK - Radiation and Nuclear Safety Authority, Finland)

B.3. Radioactive waste in Iceland (Sigurður M. Magnússon, Icelandic Radiation Safety Authority, Iceland)

B.4. Radioactive waste in Norway (Jelena Mrdakovic Popic, Norwegian Radiation Protection Authority, Norway)

B.5. Radioactive non-nuclear waste in Sweden (Erica Brewitz, Swedish Radiation Safety Authority, Sweden)

# Denmark - Management of radioactive waste of non nuclear origin

David Ulfbeck

**Nordic Meeting to Assess Possible Needs for Further Nordic Collaboration on Radioactive Waste Issues, Copenhagen, 9 June 2015**

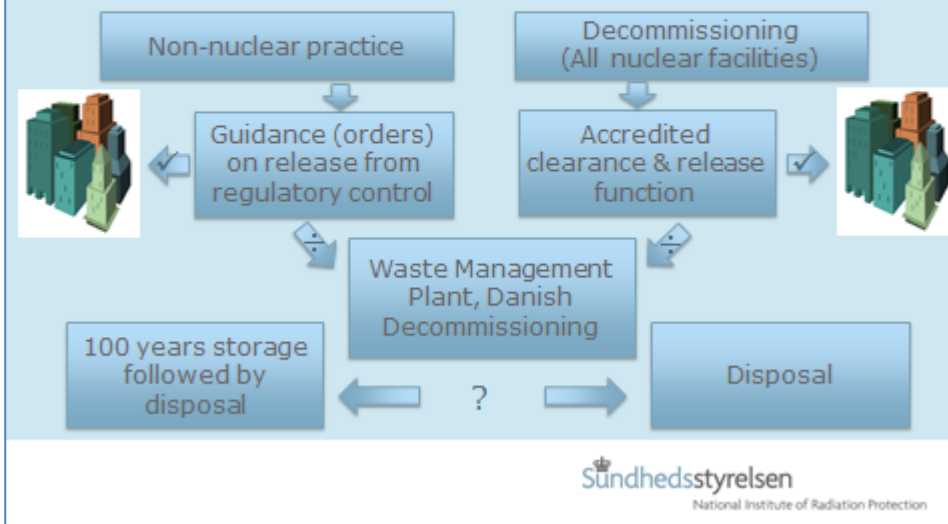
 Sundhedsstyrelsen  
National Institute of Radiation Protection

## Overview

- **Radioactive waste streams in Denmark**
- **Radioactive waste from non-nuclear applications**
  - Unsealed sources
  - Sealed sources
  - Smoke detectors
  - NORM
- **Final Management options**
  - Disposal/re-use
- **Nordic collaboration**

 Sundhedsstyrelsen  
National Institute of Radiation Protection

## Radioactive waste streams in Denmark



## Danish Decommissioning Waste Management Plant

Danish Decommissioning (DD) was established on September 15 2003 as an institution under the Ministry of Higher Education and Science. DD conducts the decommissioning of the Danish nuclear facilities and at the same time manages all radioactive waste produced in Denmark. DD also contributes to establishing a long term management solution for radioactive waste in Denmark. The waste management plant is located at the Risø peninsula.



Foto: Danish Decommissioning

# Waste inventory

## Inventory of all Danish radioactive waste (2014)

- Short lived LILW: 1.200 m<sup>3</sup> (5 TBq)
- Long lived LILW: 846 t (547 TBq)
- Tailings and ore (NORM): 4.800 t (0.1 TBq)
- Total expected inventory when decommissioning is complete: ~1500 TBq
- Total expected volume ~ 10.000 m<sup>3</sup> (incl. NORM)
- Non-nuclear waste: estimated < 500 m<sup>3</sup> (~ 100 TBq)  
(not based on a reported inventory)

# Unsealed sources

National Board of Health order no. 954:

Radionuclide grouping – broad agreement with BSS exemption limits

Group 1 radionuclides – Danish Decommissioning

Group 2, 3, 4 radionuclides:



# Unsealed sources

National Board of Health order no. 954:

Radionuclide grouping – broad agreement with BSS exemption limits

Group 1 radionuclides – Danish Decommissioning

Group 2, 3, 4 radionuclides:



Solid waste < 10 kBq/kg – “inactive”

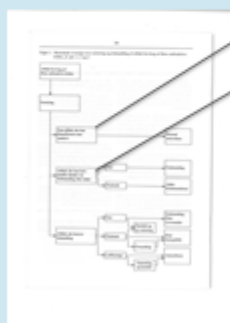
# Unsealed sources

National Board of Health order no. 954:

Radionuclide grouping – broad agreement with BSS exemption limits

Group 1 radionuclides – Danish Decommissioning

Group 2, 3, 4 radionuclides:



Solid waste < 10 kBq/kg – “inactive”

Disposal directly via drainsystem or by incineration:

Activity < 0,1 MBq/l or dose rate < 5 µSv/h  
Maximum activity discarded per month/package

Group	Activity
2	5 MBq
3	50 MBq
4	500 MBq



## Unsealed sources

### Issues for consideration

- Discharge to atmosphere from facilities (e.g. cyclotrons) is governed by dose constraints – typical 0,1 mSv/y to a critical group.
- Increase in use of nuclear medical techniques results in multiple discharges from hospitals – summing of dose constraints may be required.
- Environmental requirements for liquid discharge must include radiological considerations.
- Future proton therapy centre in Aarhus – decommissioning liability?

## Sealed sources

### National Board of Health order no. 985

#### **Disused sealed sources**

- Returned to supplier/manufacturer
- When this is not possible – transfer to Danish Decommissioning
- National data integration interface combines data from the central business register (CVR), the central person register (CPR) and the national radioactive source database, and enables timely intervention in case of bankruptcy or discontinuation for other reasons

#### **Orphan sources in scrap**

- Detected in main scrap centers by portal monitoring systems
  - 3-5 occurrences per year
  - Managed by competent operator and/or NIRP
  - Ra-226 (compasses, lightning rods etc), U-238 (shielding) etc.
  - Minor amounts of NORM

## Sealed sources

Orphan source campaign (2015)

- New guidance for scrap yards in preparation – present guidance is from 2002.
- EU council regulation No 333 states that scrap consignments must be followed by a statement of conformity with the “end-of-waste-criteria” – meaning it has been declared free of radioactivity.
- Contact points for a total number of 1493 scrap dealers have been identified.
- Emphasis on the 5-6 major national scrap yards acting as collection points

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National Institute of Radiation Protection

## Smoke detectors

National Board of Health order no. 154

- Present guidance and practice has been incineration of small detectors (3 detectors per household per month)
- Total estimated 6 million smoke detectors in Denmark
- Larger, industrial type detectors are managed by Danish Decommissioning
- Council Directive 2002/96/EC (WEEE) places smoke detectors in electronic equipment waste stream resulting in accumulation of smoke detectors in municipal recycling facilities
- New guidance to be developed

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# NORM

Ministry of the Interior and Health (now Ministry of Health) Order No. 192 on exemptions  
Guideline for the management of NORM from the oil- and gas industry.

## **NORM waste in Denmark**

- Offshore industry – oil/gas are main producers
  - Scales, sludge, contaminated pipes etc.
  - Inventory per 2010 ~ 100 m<sup>3</sup>
  - Stored at operator on-shore sites.
  - Management of NORM in Denmark is considered to be primarily a volume issue.
  - Characterization project in progress
- 
- **Future volumes?**
  - **Final Disposal?**



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## Final management options

### **Disposal:**

- Disposal of non-nuclear radioactive waste is linked to decommissioning process as well as intermediate storage/disposal decision.
- A disposal facility will accept non-nuclear radioactive waste until closure (e.g. 30 years). A storage facility will remain "open" for up to 100 years.
- In the period after closure of a disposal facility, other disposal routes are needed.
- Re-use of certain sources (e.g. smoke detectors, sealed sources) may provide alternative to disposal.
- Disposal of NORM in final repository for decommissioning waste has so far been considered a potential solution, but only for tailings stored at Danish Decommissioning.
- The bulk of future NORM waste require decision on disposal solution.

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## Nordic Collaboration

- Experience feedback regarding management of radioactive waste, orphan sealed sources, smoke detectors, contaminated objects etc. in the scrap metal/recycling industry.
- Experience feedback regarding management of smoke detectors in the Electric/Electronic Equipment waste stream.
- NORM management and development of disposal options

## Finland: overview of non-nuclear radioactive waste issues

NKS Copenhagen 9.6.2015

Mika Markkanen

### Classification of radioactive waste for disposal purposes

- Nuclear waste (not discussed in this presentation)
- Radioactive waste not originating from the use of nuclear energy and the associated nuclear fuel cycle.

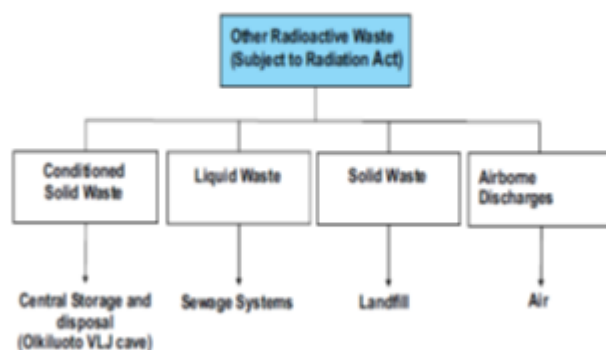


Figure 3. Classification of radioactive waste for disposal purposes.

## General requirements

- Radioactive waste
  - substances that have **no use any more** and **have to be rendered harmless** due to their radioactivity
  - radioactive substances in case **the owner** of the substances or the appliances **cannot be found**
- Responsibility lies on the body using radioactive substances or otherwise generating radioactive waste
- State has secondary responsibility
  - Responsible party fails to fulfill its management obligations
  - Origin of waste not known or now primary responsible party can be found
- Import of radioactive waste for the purpose of disposal is prohibited.

## Origin of non-nuclear waste

- Uses of radioactive sources in medicine, industry, research etc.,
  - disused sealed or unsealed sources, authorized airborne or liquid releases, decommissioning waste
- Mining and milling industry, and processing of NORM raw materials
  - milling tailings, liquid or airborne releases
- Scrap metal industry
  - radioactive objects detected within the scrap
  - waste arising from unintentional melting of radioactive sources (mainly slag and dust)
- Consumer products
  - disused smoke detectors

## Disused sealed sources

- Plan must be presented when applying for an authorization
  - Return to the provider abroad (required for all HASS sources)
  - Transfer to national long term storage
- Financial security
  - If activity is above 100 x HASS-level and  $T_{1/2} > 150$  d
  - $\text{Sum} = 10000 \text{ €} + 1000 \text{ €} \times (\text{Activity} / (100 \times \text{HASS-level}))$
  - If calculated Sum  $> 110\,000 \text{ €}$ , STUK can accept a reduced Sum based on evidence on factual current management costs
  - Bank guarantee, insurance or similar asset

## National long term storage

- A cavern in the LILW disposal facility at Olkiluoto; leased by the State from the TVO nuclear power company
- Total max volume 100 m<sup>3</sup>.
- Current inventory is 56 m<sup>3</sup> (50.14 TBq, prominent nuclides: <sup>3</sup>H, <sup>137</sup>Cs, <sup>85</sup>Kr, <sup>241</sup>Am, <sup>238</sup>Pu; situation at end of 2013).
- Annual accumulation of new conditioned and packaged waste varies between 1 – 3 m<sup>3</sup>.
- Most of this waste will also be disposed of in the same facility in the future; however, a few HASS sources will need a different disposal route, which is not yet determined.
- Disused sources are collected, repacked and transferred to the storage by a private entrepreneur, 'Suomen Nukliditeknikka' (a recognised installation licensed by STUK).

## Unsealed sources

- A common practice is that radionuclide laboratories store their short lived radioactive wastes at their premises until they have decayed below the limits set for discharges in Guide ST 6.2.
- According to Guide ST 6.2, liquid waste can be disposed of into a **sewage system** and **waste can be delivered to a landfill site or an incineration plant**, if the activities are below the **nuclide specific limits presented** in the guide.

## Decommissioning waste

- Sealed and unsealed sources treated as prescribed in above
- Contaminated or activated structures
  - Clearance, general (guide ST 1.5 ; based on IAEA RS-G-1.7)
  - Case by case approval for disposal (typically max few m<sup>3</sup>) to a normal industrial waste site
    - Approval also needed from the Environmental Authorities who regulate the disposal site as a whole.



## Mining and milling

- Talvivaara mine (heap leaching)
  - Ore contains about 20 ppm uranium (below the 100 ppm reporting level)
  - Uranium ends up into the gypsum ponds (U inventory 300 – 600 tons)
  - Miss operations and severe problems with the water balance
    - Acid waters were directed to gypsum ponds - > uranium soluble
    - Leakage of the pond 4.11.2012 -> 0.1 – 0.6 tons of U released to the environment
  - Ra, Pb, Po remain in the heaps -> no real radiological problem
  - Enormous public (=active interest groups) attention!
- Some other past and future sites...BSS directive...

## Scrap metal industry

- All important users of scrap metal have installed fixed radiation monitors at the gates of their installations.
- On an average, about 1–2 sealed radioactive sources have been found annually among imported scrap metal.
- If unbroken it may be possible to identify the source identification number – tracing for the responsible body might be possible – also across the borders.
- Orphan sources, whose owner cannot be identified, are delivered to the State interim storage at Olkiluoto.

## Scrap metal industry

- Am-241 sources difficult to detect (low gamma energy)
- Since 2006, many Am-241 sources have been accidentally melted in Outokumpu Stainless Oy's steel foundry in Tornio - despite of all possible state-of-art detection technology in use.
- After melting, Am-241 can be easily detected in slag and dust.
- Since 2010, radioactive waste arising from these occurrences (mainly Am-241 contaminated slag and dust) have been disposed in the vicinity of the foundry and covered in accordance with a plan approved by STUK.
- Many metal items with Ra-226 or Cs-137 have been found

## Smoke detectors

- Compulsory in all homes and workplaces
- Currently over 3 million detectors with Am-241 (max 40 kBq) in use
- Earlier: disposal into normal municipal waste was considered an optimized disposal solution
- WEEE directive 2003 -> electronic waste subject to recycling
- Now: smoke detectors are separated from electronic waste, and Am-241 removed by a private company
- Collected Am-241 transferred to the national long term storage

## Possible areas for Nordic collaboration

- Policies and strategies for dealing with spent sealed sources
  - commitment to return to the manufacturer
  - financial guarantee arrangements
  - how to deal with legacy sources for which returning to the manufacturer is no longer possible.
- Policies and strategies for dealing with radioactive waste arising from scrap metal industry
- Policies and strategies for the management of various types of NORM waste
  - recycling to construction materials (landfill, road construction,...)
  - disposal options.

# Radioactive waste in Iceland

Presented by Sigurður M Magnússon,

Icelandic Radiation Safety Authority



**An Iceland centred view of the Northern hemisphere:  
Iceland, a hub in the North Atlantic**



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## Sealed sources in use in Iceland

### 62 sources in use by 36 licencees.

- Largest sealed sources in use in Iceland

Number	Nuclide	Type of use	GBq
1	Cs-137	Blood irradiator	40 000
1	Ir-192	Medical	< 450
2	Am-241/Be	Well logging	111
1	Am-241/Be	Research	37
1	Cs-137	Density gauge	18.5
2	Am-241	Density gauge	11
7	Am-241	Filling height	1.7

## Open radioactive sources in use in Iceland

- Open radioactive sources are used at 5 hospitals and laboratories in Iceland this year.
- Of these 3 are in risk group C and 2 are in risk group B.
- Mo-99/Tc-99 by far the most used radionuclide.
- Store for decay before release into sewage system

## Disused sealed sources (Appendix 1 in NR to the JC 5th RM)

**Co-60**  
2 sources (4 in 2011)  
Total nominal activity: 8.5 GBq  
Largest sources: 6.9 GBq (February 1980) and 1.5 GBq (July 1991)

**Am-241**  
2 sources (6 in 2011)  
Total nominal activity: 12.8 GBq  
Largest sources: 11 GBq (December 1980) and 1.8 GBq (January 1986)

**Am-241/Be**  
3 sources (5 in 2011)  
Total nominal activity: 12.5 GBq (19.9 GBq in 2011)  
Largest sources: 11 GBq (November 1982) and 1.5 GBq (December 2004)

**Ra-226 (needles) (unchanged from previous reports)**  
A total of 37 needles are stored at the University Hospital of Iceland  
Their nominal activity ranges from 0.09 to 1.85 GBq  
Total nominal activity: 18.9 GBq (January 1967)

**Cs-137**  
6 sources (7 in 2011, 18 in 2009)  
Total nominal activity: 11.1 GBq (11.4 GBq in 2011)  
Largest sources: 2 x 4.6 GBq (January 1977)



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## Use (and discharge) of unsealed sources (Appendix 2 in NR to the JC 5th RM)

### Medical sector

#### Discharge of Tc-99

Based on the amount of Tc-99 discharged on the assumption that 100% of the amount of Tc-99m administered has decayed to Tc-99 and that it is all discharged. The actual number is highly dependent on the use of the Mo-99 generator, but the amount discharged is low: 5 kBq

#### Discharge of I-131

In 2013 the total amount of I-131 administered was 128 GBq. Based on 100% discharge of the administered dose for I-131 Ablation Therapy and 30% of the administered dose for I-131 Thyrotoxicosis treatment – for out-patients, a total discharge of 106.5 GBq is estimated.

Other radionuclides (small amounts, conservative estimate based on the reported use):

Ga-67 123 MBq  
H-3 5 MBq  
I-123 12,500 MBq  
In-111 1,800 MBq  
P-32 19 MBq

### Research laboratories

Research laboratories in Iceland (outside the medical field) use very limited amount of radionuclides and it seems to be declining. No laboratory used more than 19 MBq of any radionuclide and in most cases storing for decay has been a standard procedure for short-lived radionuclides.



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## **National programme Legal framework**

- The first legislation in Iceland on radiation protection was passed in 1962 and has been revised periodically.
- The latest major revision took place in 2002, Act 44/2002, (aim, harmonisation with EU Directives)
- Minor revisions to the radiation protection Act were made in April 2008, effective 1<sup>st</sup> January 2009 as well as in December 2013, effective on 1<sup>st</sup> January 2014.



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## **Legal framework**

- Voluntary harmonisation of Icelandic legislation and its implementation towards EU directives and their implementation in member states.
- EU Directives for radiation protection, radioactive waste have at present no legal bearing in Iceland
- Iceland is "still " a European Union candidate country.



## Regulatory body

- The regulatory authority is the **Icelandic Radiation Safety Authority (IRSA)** under the auspices of the Minister of Health.
- The Authority regulates matters concerning radiation protection, nuclear safety and security, emergency preparedness and radioactive waste.
- The scope of activities at IRSA reflect the use of ionizing radiation in Iceland – mainly medical.
- IRSA has a staff of 10 of which 7 are technical experts with an academic background.

## Radioactive waste management policy

- Radioactive waste is regulated within the framework of the Act on Radiation Protection and regulations on radiation protection based on the Act.
- These are
  - Regulation 809/2003 on radiation protection in use of open sourcesand
  - Regulation 811/2003 on radiation protection in use of sealed sources

Both regulations are being revised to reflect change in legislation effective 1. January 2014.



## Radioactive waste management policy

- Radioactive waste management policy in Iceland is based on the practical needs of the country.
- The very low activity and volume of radioactive waste does not justify a national final waste depository.
- Therefore the requirement is that disused **sealed sources** be returned to the **country of origin** or, "**disposed**" of in **another legal way** accepted by the regulatory authority **i.e. sold to another licensed user** unless they can be stored under safe and secure conditions until decayed.

## Management of disused sources.

- Some sources no longer in use are kept by the licensees, under the control of the Regulatory Authority, on their premises until decayed or returned to the manufacturer etc.
- If the storage conditions do not meet the requirements set by the radiation protection Act and regulations with regard to safety and the security of the source(s), then IRSA can request the disposal of the source and if this is not met within a specified timeframe IRSA can carry out the disposal at the licensees expense.

## Releases of liquid waste.

- Short lived liquid radioactive waste generated in medical and research facilities is stored to decay on the premises before release into the public sewage system
- Releases must be as low as reasonably achievable and within the limits set in regulation 809/2003 on radiation protection in the use of open sources. (this is based on publication *Application in the Nordic countries of International Radioactive Waste Recommendations*, published by the Nordic radiation safety authorities in 1986.
- Since the laboratories must the ALARA principle and store waste for decay, the actual releases have in practice been well below these limits by all laboratories.



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## Challenges in RW in Iceland

- Long-term management of disused sources that cannot be returned to the supplier.
- Reduction of risk of disused sources becoming orphan sources.



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## Summary

- Use of radioactive sources in Iceland is low.
- Volume of radioactive waste very low. Does not justify a national final waste depository.
- Effective system of licenses, inspections and import control – “cradle to grave approach”.
- Comprehensive register of sealed sources
- Areas for enhanced Nordic co-operation in radioactive waste not identified except possibly what to do with disused sources that can not be returned ( legacy sources ).



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**Thank you very much for  
your attention !**



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# Radioactive waste in Norway

Jelena Mrdakovic Popic

NKS Nordic Meeting, Copenhagen, 9 June 2015



## Agenda

- Norwegian legislation
- Recent requirements
- Waste generation – activities /overview
- Repositories - overview
- Current state and challenges
- Issues for potential collaboration



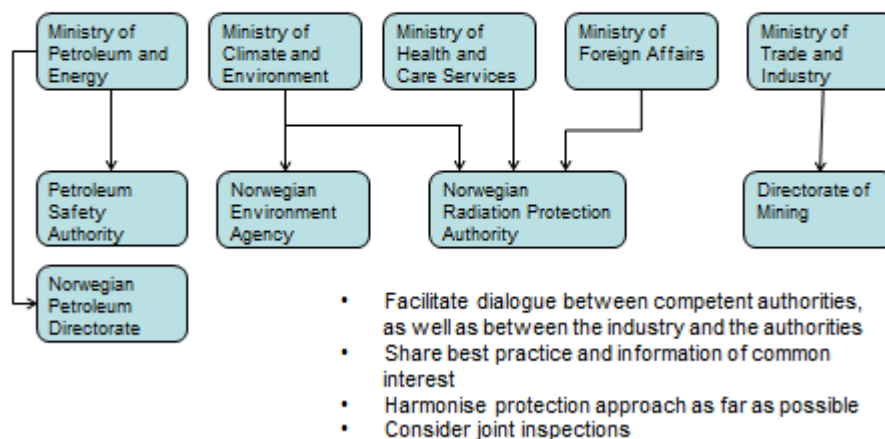
## Norwegian legislation



- **Pollution Control Act** – from 1 January 2011
  - Radioactive waste regulated alongside with other types of pollutants
  - Holistic approach to the protection of human health and environment
- **Act on Radiation Protection and Use of Radiation**
  - Associated regulations, international conventions and agreements
  - Guidance documents issued by the NRPA



## Relevant authorities for radioactive waste and hazardous waste management



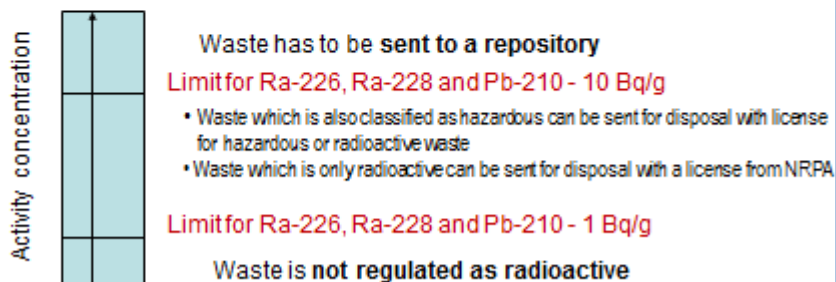
## Requirements

- Permit/license
  - ✓ Handling (including disposal) of radioactive waste,
  - ✓ Radioactive pollution
- Safe handling
- Storage
- Delivering and declaration
- Reporting
- Competence



## Radioactive Waste - tiered approach

- Values for when **waste is regulated as radioactive**
  - Based on IAEA RS-G-1.7 (and partly draft IAEA BSS 24th February 2010 and RP 122 part II), **NORM - 1 Bq/g**
- Values for when **the waste has to be sent to a repository**
  - Based on IAEA BSS, E.g. Ra-226, Ra-228 and Pb-210 10 Bq/g
- Three tiers approach



## Declaration of waste

- NORM waste is most often also classified as hazardous waste
  - ✓ Heavy metals, oil etc.
- Requirements in the legislation are very similar to requirements for hazardous waste
- Similar system for classification of radioactive as hazardous waste
- Radioactive waste has to be declared
  - ✓ Same form as for hazardous waste,
  - ✓ Both radioactive and other characteristics
  - ✓ Easier for the industry and overall information to the authorities
- From 2015 declaration of waste is done online

## Numbers and facts

- NRPA have issued 165 permits in time period 2011 - 2014 to about 70 companies

Year	Number of declarations	Tonnes of rad.waste
2011	310	17 730
2012	279	41 538
2013	352	31 600
2014	582	13 128

## Radioactive waste in Norway



- Radioactive waste registered in 2014: 13 128 tonnes (87% is radioactive rock waste, mostly alum shale)
- Waste generated in the following practices and activities:
  - ✓ Orphan sources
  - ✓ Uses of radioactive sources in health sector
  - ✓ Uses of radioactive sources in research institutes
  - ✓ Oil and gas industry
  - ✓ NORM mining and processing activities
  - ✓ Use of radioactive sources in some consumer products



## Combined source register and notification system

- All radiation sources subjected to authorization or notification (sealed and open radioactive sources)
- Notification of information concerning:
  - ✓ the responsible organization
  - ✓ the source and the shielding containment
  - ✓ returning agreement
  - ✓ identification numbers
- Completely new system adopting these days





## Disposal of radiation sources and Regulations on Radiation Protection and Use of Radiation

### § 13. Disposal of radiation sources

- Undertakings that procures sealed radioactive radiation sources have a duty to assure that a return scheme exists in the country of origin and to utilize that scheme. Furthermore, the undertaking has a duty to inform the Norwegian Radiation Protection Authority of the return scheme in connection with authorization or notification under Sections 8 and 12.
- Undertakings that dispose or transfer radiation sources subject to authorization or notification under Sections 8 and 12 to new users, through a return scheme or to a waste disposal facility shall notify this to the Norwegian Radiation Protection Authority. For open radioactive radiation sources it is sufficient that the undertaking has updated lists of radionuclides and activity quantities.



## Radioactive sources still end up among scrap metal

- **In Norway:**  
Around 2-3 'lost' radioactive radiation sources found per year  
One half found in entrance portals  
But no radiation sources melted in other metal production processes
- Typical sources: Cs-137 (48%) and Co-60 (26%)  
+ Am-241, Ra-226 and Th-232.
- Two radioactive sources of Co-60 were found in smelter in Mo i Rana (Norway) in October 2008
- Information of two additional lost Co-60 sources of same origin came in addition



## Health sector waste

- NRPA issues permits to hospitals to release radioactive substances into a sewage system (and air)
- In total, 4.53 TBq discharged into the environment from hospitals in Norway in 2014
  - ✓ Contribution of Tc-99m, I-131 and F-18 is about 98%
- Collected radioactive waste: 4.56 tonnes was sent for disposal from hospitals in Norway in 2014



## Research activities

- Open radioactive sources - 15 research laboratories
  - ✓ The most common radionuclides are H-3, C-14, I-125, P-31, Cr-51, S-35, P-33, Cs-134, Cs-137, Cd-109
- Generated radioactive waste: 24.48 tonnes declared in 2014



## **NORM industries in Norway**

The industries in red are present in Norway, Oil and gas industry is by far the largest

- Extraction of rare earths from monazite
- Production of thorium compounds and manufacture of thorium containing products
- Processing of niobium/tantalum ore
- **Oil and gas production**
- **TiO<sub>2</sub> pigment production**
- Thermal phosphorus production
- Zircon and zirconium industry
- **Production of phosphate fertilisers**
- **Cement production, maintenance of clinker ovens**
- Coal-fired power plants, maintenance of boilers
- Phosphoric acid production,
- **Primary iron production,**
- **Tin/lead/copper smelting,**
- Ground water filtration facilities,
- **Mining of ores other than uranium ore**
- ...

(European Commission: "European Commission Services considerations with regard to natural radiation sources in BSS Directive", 16.01.2009)



## **Oil and gas industry**

- 76 oil and gas production platforms
- Radioactive waste consists of quantities of produced water, scales, sludge, and loose material from production
- Radionuclides of concern: Ra-226, Ra-228 and daughter products
- Contaminated equipment



## Waste numbers – oil and gas industry

- Current calculations of radioactivity discharge to the environment via produced water in 2014:

402 GBq of Ra-226, 348 GBq of Ra-228 and 19 GBq of Pb-210

- About 350 tonnes of different types waste from oil and gas industry declared in 2014
- Decommissioning of offshore installations

Table 1. Estimated waste in decommissioning 2010-2020 (Klit, 2010)

Norge	Radioactive scale (tonnes)		Total waste 2010-20 (tonnes)
	2010-15	2015-20	
Big platforms	42	54	96
Small «steel jacket» platforms	0	0	0
Subsea systems	No data	No data	No data
Total i Norge	42	54	96



## Radioactive waste management - NORM stream example



- Waste management companies
- Cleans contaminated equipments



Repositories for radioactive waste



## Waste routes for NORM from the Oil and gas industry

- 10 companies have license from NRPA to clean NORM waste from process equipment, and 3 more have applied for license
- Waste disposal
  - Offshore
    - Waste can either be re-injected or taken to shore
  - Onshore
    - Sum of activity between 1Bq/g and 10Bq/g and low hydrocarbon content  
**NOAH-repository**
    - Sum of activity between 1Bq/g and 10Bq/g and high hydrocarbon content  
**Lack of suitable disposal facility**, but at least one company in contact with NRPA with a plan for disposal facility
    - Sum of activity above 10Bq/g regardless of hydrocarbon content  
**NORM Stangeneset repository** for waste from oil and gas industry
- Decommissioning
  - 4 decommission sites; companies must have license from NRPA



## NORM waste

- 11 390 tonnes of radioactive material in form of excavated rocks (stones) in 2014, respectively
- Disposal sites NOAH and Borge
- NORM in rocks with acid drainage potential – a challenge for Norway
  - ✓ large volumes of already excavated rocks (that potentially may be radioactive waste/or cause radioactive pollution)
  - ✓ planned construction projects in alum shale areas (more large volume waste)
  - ✓ current lack of disposal sites



## Alum shale – source of radioactive waste and pollution (ongoing work)

- Large quantities of alum shales in Norwegian Counties Akershus, Oslo, Oppland, Buskerud og Hedmark
- Variable  $^{238}\text{U}$  concentration in alum shales
  - High  $^{238}\text{U}$  leads to high  $^{222}\text{Rn}$  air levels – indoor radon problems
  - Oxidation, acidic leachate and mobilization of  $^{238}\text{U}$  chain radionuclides



Alum shale deposited in nature – without permit (source: NRPA)



## Alum shale – source of radioactive waste and pollution (ongoing work) cont'd

- ***Alum shale - a potential hazard during construction of the roads, tunnels or other exploitation in Norway***
- Legal requirements for handling of alum shale radioactive waste
  - screening for  $^{238}\text{U}$  levels in rocks (if  $> 1 \text{ Bq/g}$  radioactive waste)
  - permit from NRPA for radioactive pollution release if it is actual when alum shale rocks are excavated
  - safe handling of alum shale rock masses
  - disposal of excavated masses to disposal facilities with proper license
  - declaration of radioactive waste



## **NORM from mining activities**

- Neither radioactive waste nor radioactive pollution in existing mines in operation ☺
- Legacy mines – several cases
  - ✓ Søve, former Nb mining site in eastern Norway
  - ✓ Oterstranda, former Mo mining site in northern Norway
  - ✓ Ongoing activities for clean-up operation and for assignment of responsibility for restoration at Søve and Oterstranda, respectively



## **NORM processing Industries**

- *Titanium dioxide production* – In 2014 was 100 tonnes of ESP dust with Po-210 and Pb-210 1231 MBq and 1931 MBq, respectively.
- *Phosphate production* – Yara, (Porsgrunn and Glomfjord).
  - ✓ NRPA gave the permit for discharge U-nat and Th-nat into the environment
  - ✓ 6.19 MBq and 0.45 MBq of U-nat and Th-nat, respectively, were discharged to the environment in 2014.



## Radioactivity in disused smoke detectors

- According to IFE's annual report, approx. 2 GBq of Am-241 from ICSDs was disposed of in 2014.
- According to the regulations, ICSDs follow the waste route of WEEE.
- After collection and sorting, ICSDs are dismantled manually at special facilities and radioactive waste from ICSDs is sent to IFE's Combined Disposal and Storage facility for low and intermediate-level waste in Himdalen.



## Authorized disposal sites for radioactive waste

- Senja Avfall IKS - incineration
- The Combined Disposal and Storage facility for low and intermediate-level waste of Institute for Energy Technology (IFE) in Himdalen - 4 mountain halls, at the moment 3 for final disposal and 1 for storage





## Authorized disposal sites for radioactive waste (cont'd)

- NOAH Holmestrand
- Wergeland Halsvik AS - Stangeneset



## NOAH repository



NOAH Langøya AS, currently and plans for recovery of the island after closure



## **Some of the conditions for NOAH repository set by the NRPA**

- Waste with NORM
- Discharges of radioactive substances from process water
  - Analyze for at least Pb-210, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, U-238 and Cs-137
  - Daily subsamples in a monthly sample- report include uncertainty
- No leakage of radioactive substances to the environment
- Monitoring of the environment around the facility
  - Water, sediment, mussels
- Available updated journals
- Annual reports to the NRPA
  - Considering BAT, doses to workers, results from the environmental monitoring, amounts of waste received and deposited etc.



## **Some of the conditions for NOAH repository set by the NRPA**

- Changes to the work procedures have to be sent to NRPA before implemented
- Financial security
  - To secure management of the waste and closing of the repository in case of NOAH AS is not able to run the repository
  - To secure safe post operative phase



## Stengeneset – Wergeland Halsvik

- Established for NORM waste from the petroleum industry in 2008
- Now they may receive NORM waste in general
- May deposit 1500 tons per year



## Capacity and further needs

- In the next 30 years it is assumed that about 3000 tons of waste will be produced from the petroleum industry (estimated in 2010)
- The capacity of the repository is today 7000 tons
- There are possibilities for further expansions



## Some conditions set by the NRPA I

- State guarantee in case of Wergeland-Halsvik AS is not able to run the repository
- Financial security
  - To secure management of the waste and closing of the repository in case of NOAH AS is not able to run the repository
  - To secure safe post operative phase



## Some conditions set by the NRPA II

- No leakage of radioactive substances to the environment from repositied waste
- Water arising during treatment of waste shall be measured for radioactivity and if necessary cleaned before released
- Annually monitoring program of the environment around the repository including testing of ground water, treatment water, sea water, sediment, benthic fish, soil, vegetation and the rock formation
- Available updated journals
- Annual reports to the NRPA
  - Considering BAT, doses to workers, results from the environmental monitoring, amounts of waste received and deposited etc.
- Changes to the work procedures have to be sent to NRPA before implemented



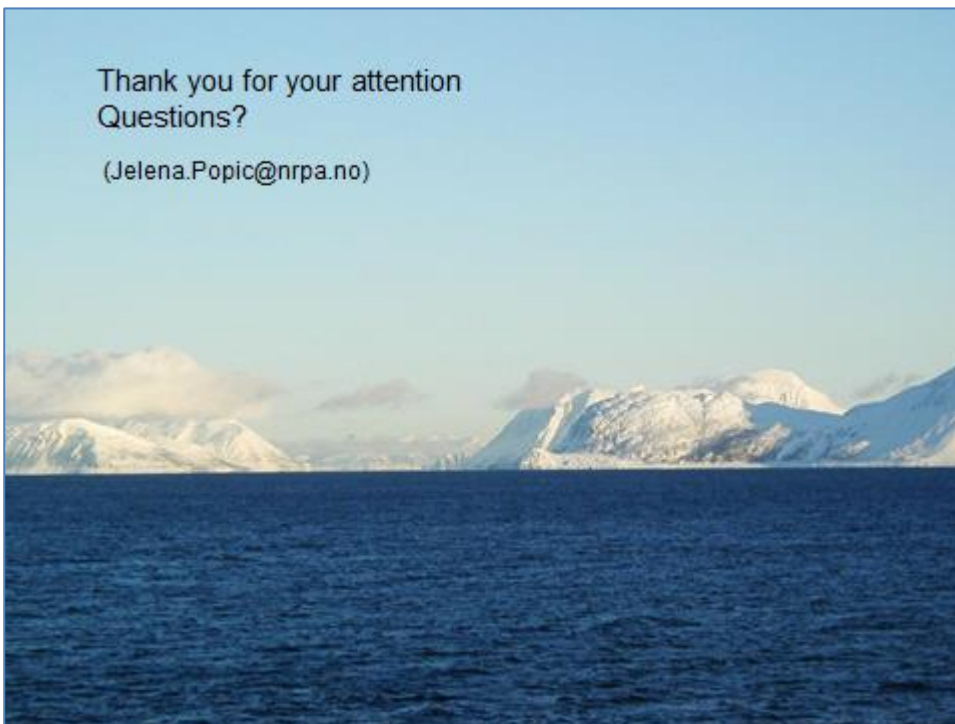
## Topics for potential collaboration

- NORM waste in process industries in Nordic countries – overview of current status, legislation, comparison of practices and experiences (case study)
- NORM waste at legacy mining sites – comparison of legislative requirements, practices and experience exchange
- Orphan sources – practices and experiences how to deal with legacy sources for which returning to the manufacturer is no longer possible- military sources for instance
- Thorium and uranium as by-products in some industries



Thank you for your attention  
Questions?

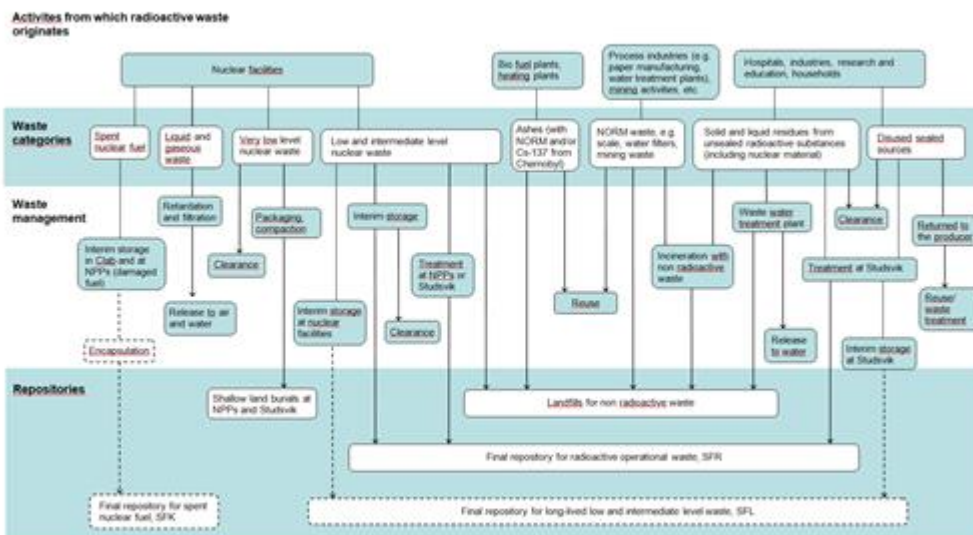
(Jelena.Popic@nrpa.no)



## Radioactive non-nuclear waste in Sweden

Erica Örnqvist  
2015-06-02

### Overview – the Swedish RWM system



Erica Örnqvist  
2015-06-02



## Radioactive waste to geological disposal

Waste fractions based on final disposal solution	Volumes in SFR (m <sup>3</sup> )	Volumes in SFL (m <sup>3</sup> )
Already sent to SFR	93	
Stored at Studsvik, planned repository: SFR	88–81	
Generated annually, planned repository: SFR	3.5–5.6	
Stored at Studsvik, planned repository: SFL		56
Generated annually, planned repository: SFL		1.4

### → ESS

- Planned start of operation: 2025
- Operation 40 y
- Estimated total amount of RW from operation and decommissioning: approx 11 000 m<sup>3</sup>

Erica Örnvitz  
2015-06-05

## When the Swedish RWM system does not work for non-nuclear RW

- The "owners" consists of many diverse, small companies/organisations.
- The problematic waste categories are too small.
- Difficulties financing projects to come up with solutions and difficult to find cost-effective solutions.
- Also: The system for orphan source management shows that money does not solve all problems.

Erica Örnvitz  
2015-06-05



## Recycling, reuse

- Krypton-85 in sealed sources
  - Studsvik denied for several years
  - exported for recycling/reuse since 2011
- Tritium in sealed sources
  - Recycling/reuse option available abroad
- Depleted uranium
  - possible recycling/reuse solution abroad
- Smoke detectors
  - appr 130 000/y collected and dismantled
  - Recycling/reuse option available abroad

Grice Grenville  
2015-06-05



## Radioactive material in scrap metal and metal products (1)

- NORM, scale in pipes etc
  - approx 60-80 tonnes stored in different locations today
  - a few tonnes collected per year
  - Melting option available abroad
  - Several items found in scrap from Norway ...
- Orphan sources and legacy waste
  - Very close to everything that has been found so far has been managed.
  - Orphan sources have been melted, last time: Am-241 spring 2015

Grice Grenville  
2015-06-05





Erica Shewitz  
2015-06-05



## Radioactive material in scrap metal and metal products (2)

- Weak border control
  - For security purposes: one Megaport (USA), Customs has a couple of mobile units
  - Two known incidents with imported – and exported – Co-60 contaminated products

Erica Shewitz  
2015-06-05



**Thank you!**



Erica Greiner  
2015-06-05

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Title	An overview of current non-nuclear radioactive waste management in the Nordic countries and considerations on possible needs for enhanced inter-Nordic cooperation
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No. of pages	89
No. of tables	2
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Abstract max. 2000 characters	This report is the final deliverable of a project commissioned by the Nordic Council of Ministers for NKS to assess the current situation in the Nordic countries with respect to management of non-nuclear radioactive waste. The ultimate goal was to examine if any needs could be identified for enhanced Nordic cooperation within the area. The radiation safety authorities in the Nordic countries were all asked to produce a current status report including thoughts about possible needs for enhanced cooperation. The material was presented and discussed at a meeting in Copenhagen of representatives of NKS and the Nordic authorities, and a number of ideas were derived with the perspective of possible further cooperation between the Nordic countries on the regulatory level, whereas

more scientific based new work ideas were thought to be suited for an activity application for the next NKS call for proposals, in the autumn of 2015.

Key words

Radioactive waste, non-nuclear, waste management, NORM, Nordic cooperation, orphan sources, sealed sources, scrap metal sources, geological disposal.